RADIO-CRAFT LIBRARY No. 20

THE CATHODE-RAY OSCILLOSCOPE

THEORY AND PRACTICAL APPLICATIONS

By Charles Sicuranza

PUBLISHED BY
RADCRAFT PUBLICATIONS, INC.
99 HUDSON ST.-NEW YORK

Price
$10.00

Servicing Radios is Made Easier with the NEW Gernsback Manual

VOLUME 7

1,800 PAGES

RADIO's newest of service manuals—published by the House of Gernsback. VOLUME 7 OFFICIAL RADIO SERVICE MANUAL contains many features never previously published in any service guide. This edition is the most outstanding GERNSBACK Manual published since 1931.

• *Feotures of Volume 7 Officiol Rodio Service Manual* •

- **Over 1,800 Pages**
- **Over 3,000 Illustrations**
- **Over 1,600 Sets Represented**
- Complete Service Data
- Includes 1938 Models Not Found in Other Manuals
- All New Material—No Reprint or Rehash
- Operating Voltages for Over 85% of the Sets
- Intermediate Frequencies of All Superheterodynes
- Full Alignment Procedure for Over 75% of the Superheterodyne Receivers Listed
- Full Cathode-Ray Oscilloscope I. F. Alignment Procedure for Many of the Complicated Superheterodyne Receivers
- Simple Mechanism Permits Pages to Be Easily Removed and Re-inserted
- Stiff, looseleaf covers—size, 9 x 12 Inches
- A Master Index of 74 Pages Includes Sets Listed in All the Gernsback Manuals Since the Publication of Volume 1 in 1931.

Send remittance of $10.00 by check or money order for your copy of VOLUME 7 GERNSBACK OFFICIAL RADIO SERVICE MANUAL. If you send cash, or unused U. S. Postage stamps, register your letter. YOUR MANUAL IS SENT TO YOU POSTPAID.

RADCRAFT PUBLICATIONS, INC.
99-CR HUDSON ST. NEW YORK, N. Y.

THE CATHODE-RAY OSCILLOSCOPE

THEORY AND PRACTICAL APPLICATIONS

BY

CHARLES SICURANZA

RADCRAFT PUBLICATIONS, INC.

PUBLISHERS

99 HUDSON STREET • NEW YORK, N. Y.

Copyright 1938 by Hugo Gernsback

Printed in U. S. A.

Table of Contents

Chapter I—Theory and Function of Cathode-Ray Tubes Page 4

(1) How the electronic beam is formed.
(2) How the beam is controlled.
(3) How the beam is made visible on the screen.
(4) How the screen is made, and its purpose.

Chapter II—Power Supplies and Associated Circuits Page 10

(1) Hi-voltage power supplies.
(2) Low voltage power supplies.
(3) Filter systems, several types.
(4) Voltage-divider systems.
(5) Beam-control systems, shift, focus, centering and intensity controls defined.

Chapter III—Sweep Circuits Page 16

(1) The saw-tooth oscillator, a brief but complete explanation of its functions.
(2) The 60-cycle sweep and its applications.
(3) External sweeps, and how to apply them.
(4) Mechanical sweep circuits, their use and purpose.

Chapter IV—Operation of a Typical Unit Page 22

(1) Focusing (2) Centering the spot 3) Synchronizing
(4) Spot intensity (5) Vertical and Horizontal amplifiers, their purpose and uses.
Constructional details, Thordarson Oscilloscope Kit.

Chapter V—Methods of Measurement Page 33

(1) How to use the oscilloscope as a voltmeter, ammeter or ohmmeter.
(2) How to connect the oscilloscope and its internal amplifiers to apparatus under test.
(3) How to interpret the viewed image, in terms of cycles, volts or phrase degrees.

Chapter VI—Practical Applications of Cathode-Ray Oscillographs Page 39

(1) Servicing receivers.
(2) Checking transmitters.
(3) Checking Sound systems.
(4) Checking operation of new-design models.
(5) Other practical uses.
(6) Constructional details of a 3" home-made Oscillograph.

Chapter VII—Solving Unusual Problems With the Oscillograph Page 58

(1) Adjustment of AFC.
(2) Tracing inductive hum-pickup.
(3) Adjusting 10-kc. filter in Hi-Fi Receivers.
(4) Determining low and high frequency limits of amplifiers.
(5) Determining low and high frequency limits of wave filters.
(6) Determining low and high frequency attenuation of filters.

Introduction

THE Cathode-Ray Oscilloscope is used to-day in practically every branch of electrical engineering, and is being used more and more in other branches of industry because of its unique abilities. Its greatest value lies in its ability to define visually and trace alternating voltages of almost any frequency and complexity. Its versatility of application in the solution of measurement problems is almost endless. Aside from its uses in the laboratory, it has become an invaluable boon to the experienced Radio Service Engineer.

This book has, as its aim, an effort to help the Radio Service Man to acquire a broader knowledge of the why and wherefore of the Cathode-Ray Oscilloscope.

The following pages are dedicated to a simple and non-mathematical exposition of the theory and practical applications of the Cathode-Ray Oscilloscope, particularly stressing its uses in the field of Radio Service.

We are not, however, forgetting our fellow workers, the "ham" and the experimenter. For their benefit, we will describe the construction and operation of oscilloscopes ranging in size from one inch to nine inches, including kits, commercial units, and a home-made instrument.

We believe that the ultimate form of television receivers will embody a Cathode-Ray tube of a form similar to those in use in present-day Cathode-Ray Oscilloscopes.

A basic knowledge of the functions of Cathode-Ray tubes in general is a prime requisite toward the understanding of how Cathode-Ray tubes are used in Television.

THE AUTHOR.

THE CATHODE-RAY OSCILLOSCOPE

●

CHAPTER 1

Theory and Function of Cathode-Ray Tubes

Modern Cathode-Ray tubes are based on the theory that electrons in a vacuum tube can be gathered into a narrow beam which, upon striking a chemical coating at the end of the tube, causes the chemical to become fluorescent; thus producing a spot of light.

This electron beam has no weight and practically no inertia. Being of a negative nature, it is readily influenced by a positive charge of any kind. Thus the electron beam *can* be made to move at a rate of speed which is almost inconceivable. These positive charges are applied through the medium of Deflecting Plates, either within or outside the tube, and may be either electrostatic or electromagnetic in nature.

Since the makers of Cathode-Ray tubes must follow optical laws in the construction of the "electron gun," there is no appreciable difference in function between tubes of a given size. The better to illustrate the function of the "electron gun," we will dissect one into its component elements. In common with other vacuum tubes, Cathode-Ray tubes use a heated cathode as the *source* of the electron beam. Fig. 1 shows a cutaway view of a typical cathode element. It is a hollow tube, chemically coated on its outside surface and heated from within by the filaments. When the cathode is sufficiently heated, electrons are "boiling" on the outside surface, and a large number of electrons are liberated from the surface. These electrons form a cloud all around the cathode, similar to a cloud of steam above a boiling teakettle.

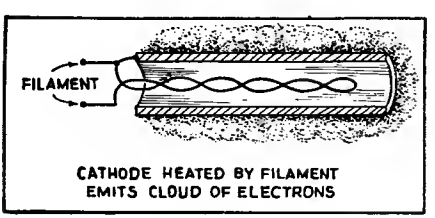


Fig. 1.

These electrons constitute a negative charge, which is attracted by the positive charge on Anode No. 1, Fig. 2 shows the action. In actual construction, Anode No. 1 is a cylinder with one end open and the other end closed, except for a small hole in its center. This anode attracts the negative electron cloud, which gathers velocity rapidly. A small portion of the electron stream shoots through the pin hole in the form of a narrow beam, traveling at terrific speed. Varying the amount of positive charge on Anode No. 1 makes it possible to control the volume of the electron stream; for this reason, Anode No. 1 is more usually called the Focusing Element.

The beam, after leaving the pin hole in Anode No. 1, has a tendency to spread outward, like the rays projected by a flashlight. In this form, the beam would have no prac-

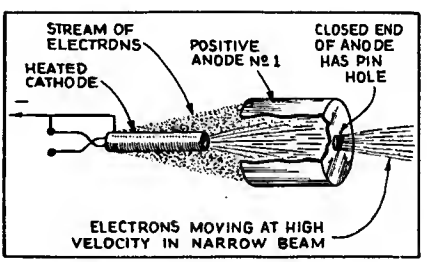

STREAM OF ELECTRONS
POSITIVE ANODE № 1
CLOSED END OF ANODE HAS PIN HOLE
HEATED CATHODE
–
ELECTRONS MOVING AT HIGH VELOCITY IN NARROW BEAM

Fig. 2.

tical use, because the spot on the screen would be very large and blurred. The necessity of adding Anode No. 2 now becomes obvious; this element is so placed with relation to Anode No. 1 that it will prevent the beam from spreading. In practical tubes, the potential on Anode No. 2 is three or four times as great as the potential on No. 1. The Anode No. 2 voltage on a 3-inch tube, for instance, is 1100 volts; on a 5-inch tube, this is increased to 2000 volts.

The high voltage accelerates the negative beam to such speed that the part of the beam which passes through the pin hole impacts upon the screen with enough force to make the coating glow brilliantly. Anode No. 2 is called the Accelerating Anode for this reason. Fig. 3 shows how Anode No. 2 attracts the beam and prevents it from spreading.

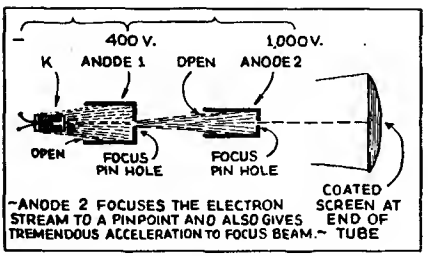


Fig. 3.

The fourth important element is the grid, shown in Fig. 4. This element is placed between the cathode and Anode No. 1 for the purpose of controlling the INTENSITY of the beam. The grid is always negative, and the amount of its negative bias determines whether the spot on the screen is bright or dim.

A brief summation of the function of the four elements would then be:

(1) Cathode—source of electrons.
(2) Grid—controls *brilliancy* of spot.
(3) Anode No. 1—controls *size* of spot.
(4) Anode No. 2—controls *velocity* of beam forming spot.

In Fig. 5 is shown the appearance of a complete tube. Note the two pairs of Deflecting

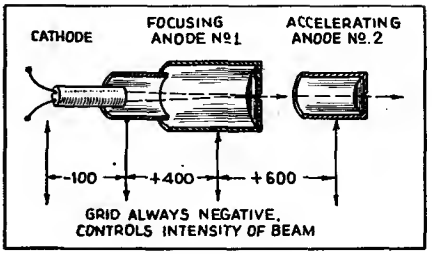


Fig. 4

Plates; the beam is shown passing through both sets of plates. If a D. C. voltage is applied across the *vertical* plates (nearest the gun) then the plate which is positive will attract the beam, while the plate which is negative will repel the beam. The spot will then be seen to have moved up (or down) a certain distance from its normal position at center. Reversing the polarity of the D. C. voltage will make the spot move in the opposite direction. In the same manner the spot can be moved horizontally across the screen by placing the D. C. voltage on the *horizontal* plates. As will be seen later, this one spot can be made to pass over any part of the screen, and with such rapidity as to *appear* as a solid disk of light. This is due to the inability of the eye to follow the spot's rapid back-and-forth, or up-and-down, motion on the screen. Another method of deflecting the beam is by placing four electro-magnet coils outside the neck of the tube; one pair of magnets is used for vertical deflection, and the other pair for horizontal deflection.

We need not concern ourselves too much with this method because it is used to no great extent, even in laboratories, and not at all in service work.

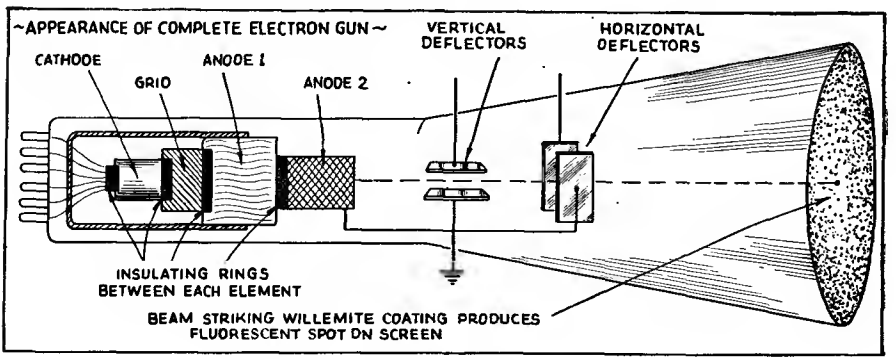


Fig. 5.

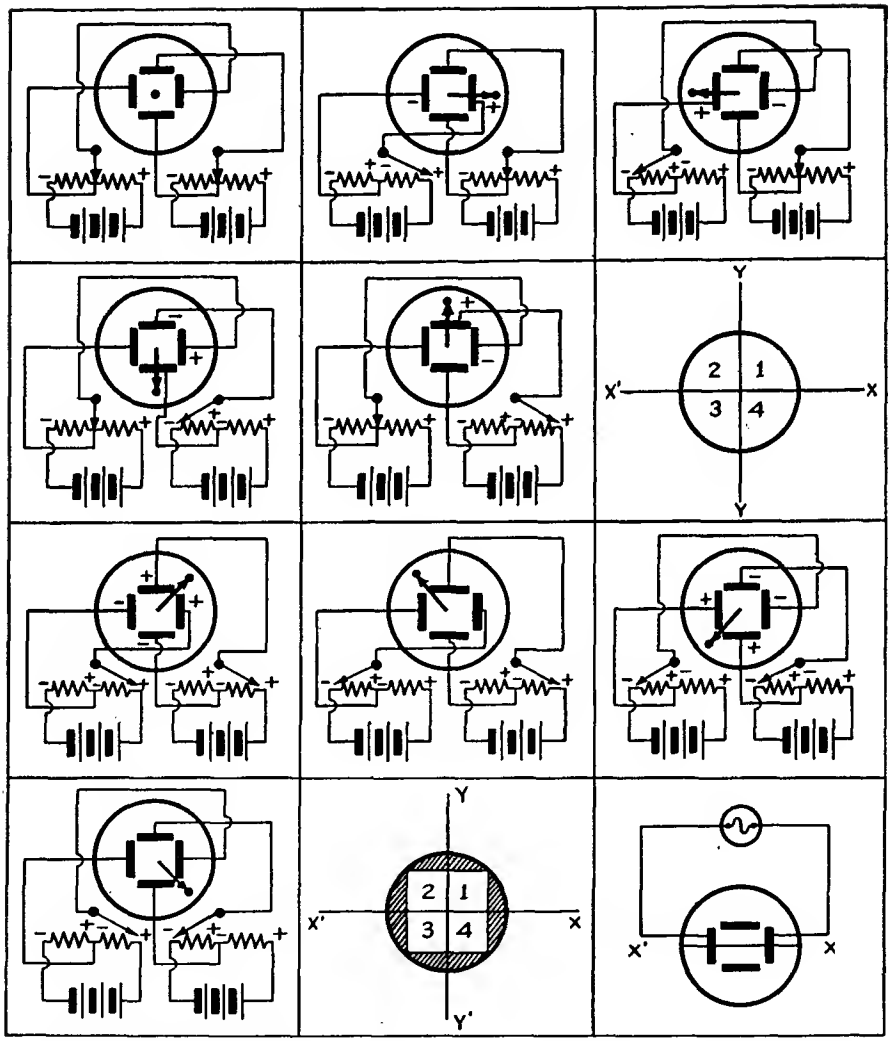


Fig. 6. Demonstrating how the "spot" may be moved to any position on the tube screen.

Fig. 7. Above
Model 546 Supreme 3″ Oscilloscope

Fig. 8. Above
Model 535 Supreme 2″ Oscilloscope

Fig. 9. Below
Sine Wave Analysis

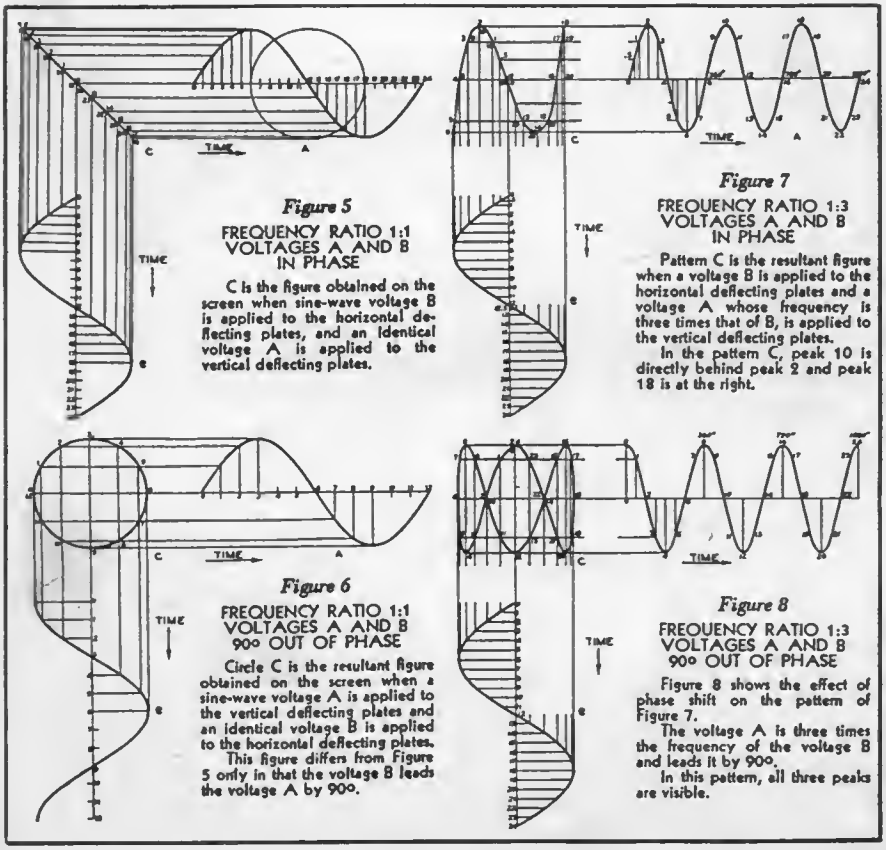


Figure 5
FREQUENCY RATIO 1:1
VOLTAGES A AND B
IN PHASE

C is the figure obtained on the screen when sine-wave voltage B is applied to the horizontal deflecting plates, and an identical voltage A is applied to the vertical deflecting plates.

Figure 7
FREQUENCY RATIO 1:3
VOLTAGES A AND B
IN PHASE

Pattern C is the resultant figure when a voltage B is applied to the horizontal deflecting plates and a voltage A whose frequency is three times that of B, is applied to the vertical deflecting plates.

In the pattern C, peak 10 is directly behind peak 2 and peak 18 is at the right.

Figure 6
FREQUENCY RATIO 1:1
VOLTAGES A AND B
90° OUT OF PHASE

Circle C is the resultant figure obtained on the screen when a sine-wave voltage A is applied to the vertical deflecting plates and an identical voltage B is applied to the horizontal deflecting plates.

This figure differs from Figure 5 only in that the voltage B leads the voltage A by 90°.

Figure 8
FREQUENCY RATIO 1:3
VOLTAGES A AND B
90° OUT OF PHASE

Figure 8 shows the effect of phase shift on the pattern of Figure 7.

The voltage A is three times the frequency of the voltage B and leads it by 90°.

In this pattern, all three peaks are visible.

Fig. 10
Model 530
Supreme
Oscilloscope

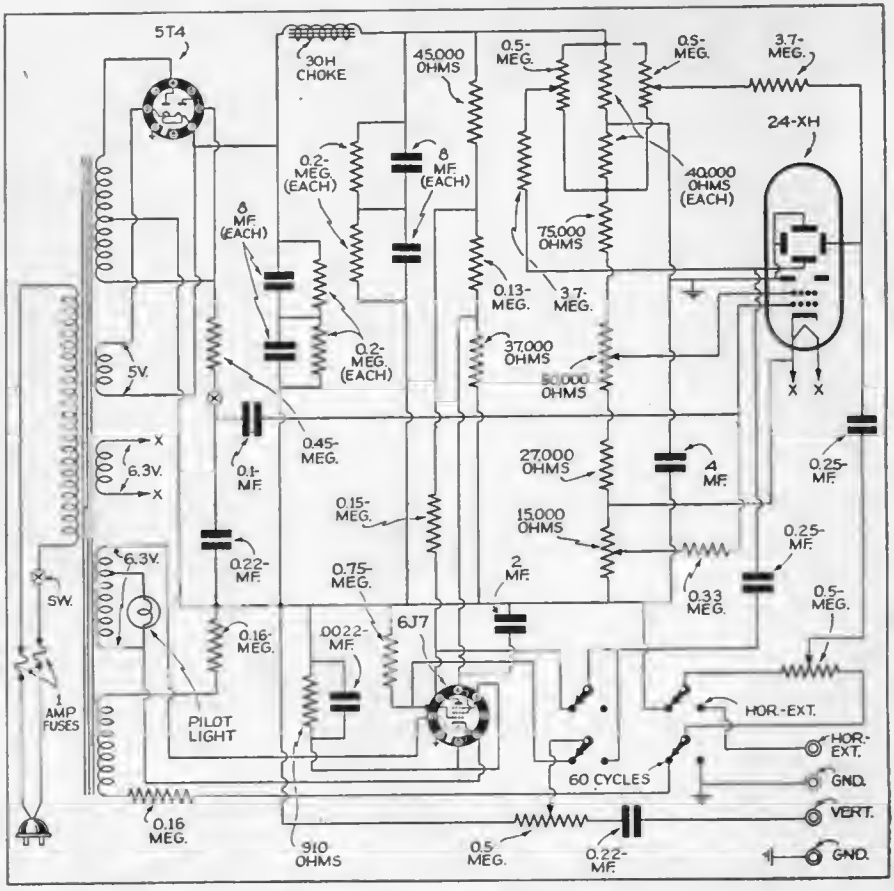


Fig. 11. Schematic of Model 530 Supreme Oscilloscope.

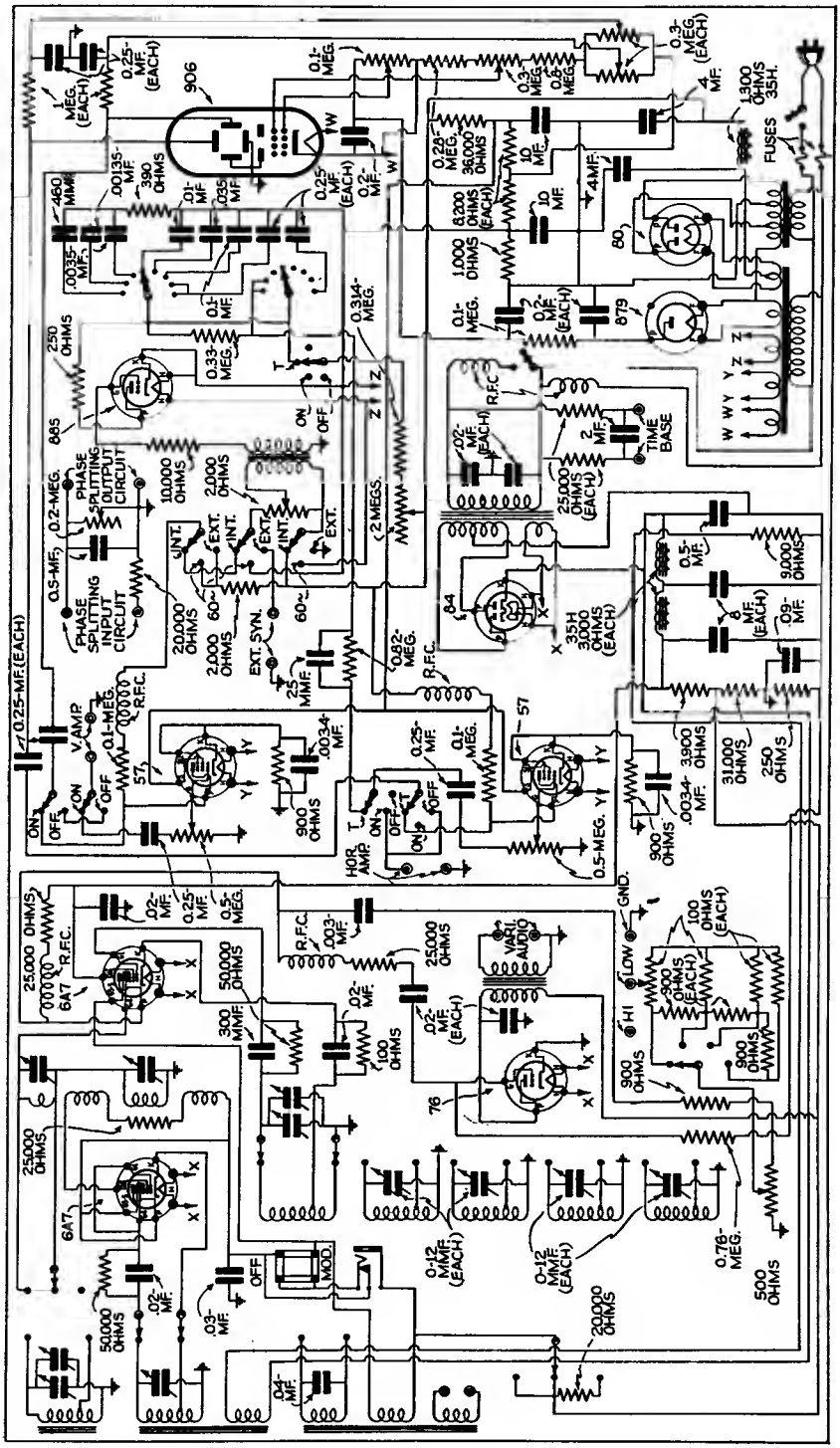


Fig. 12. Diagram of Model 555 Supreme Diagnomoscope.

CHAPTER 2

Power Supplies and Associated Circuits

The power supplies used with modern Cathode-Ray Oscillographs all have one feature in common, that is they are characterized as having high voltage output with very low current drain.

The highest voltage encountered in commercial practice is of the order of 4000 volts, which is required in the 9-inch Cathode-Ray tube. The 5-inch tubes require 2000 volts, while the 3-inch tubes work very well with 1000 volts. The remaining two sizes of Cathode-Ray tubes are the 2-inch which operates at 600 volts and, last, the 1-inch tube working at 400 volts.

We wish to repeat the warning which all manufacturers include in their instruction books: that *the high voltages used in Cathode-Ray circuits are dangerous.* As a matter of fact, the 4000 volts used in the 9-inch Oscillographs can cause *instant death.* The warning is especially intended for experimenters who like to build equipment on the breadboard plan with all wires exposed.

Another feature, which seems to be common to all power supplies, is the grounding to chassis of the *highest* potential. To those not acquainted with the reasons behind this procedure, the system seems to be all wrong; and the complex voltage-divider networks usually add to this impression. The main reason for grounding to chassis is that Anode No. 2, which receives the highest potential, is physically close to the deflecting plates. Since one deflecting plate of each pair is grounded to chassis, there would be a *potential difference,* between Anode No. 2 and these grounded plates, of anywhere between 400 and 4000 volts, depending on the tube and circuit. The probability of a flash-over between Anode No. 2 and the grounded deflector would, naturally, be greater, the higher the voltage used.

Because of the very small current required in Cathode-Ray tubes, the filter systems required to smooth out A. C. ripple are very simple; in most cases consisting of a single 0.5-mf. condenser, or a single "pi" section consisting of two condensers (usually 0.25 -mf. each) with a 100,000-ohm resistor between them.

For a clearer understanding of these power supplies in general, we shall break down a representative supply used with the 3-inch Cathode-Ray tube.

. See Fig. 13, which shows the circuit with the high potential side ungrounded, in the usual manner. Next we show, in Fig. 14,

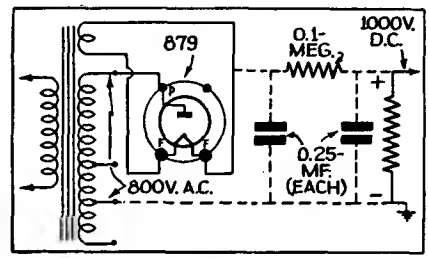


Fig. 13.

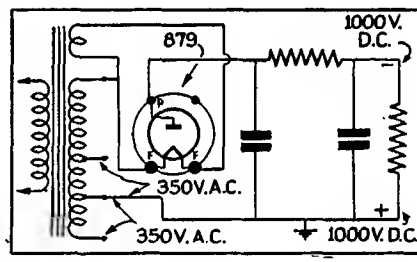


Fig. 14.

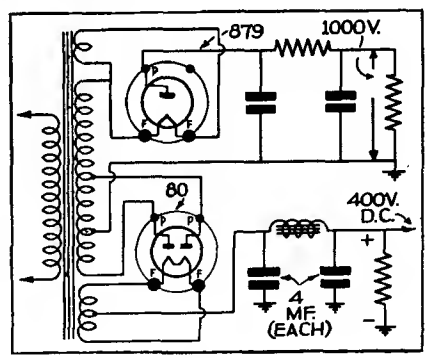


Fig. 15.

the same circuit with the high-potential side grounded. Then, in Fig. 15, we add the low-voltage rectifier, which supplies current to all the other tubes in the circuit. Finally,

in Fig. 16, we include the voltage divider and beam-shifting network. The complete circuit is used in the RCA Cathode-Ray Oscillograph, type TMV-122-B. Thus a study of the schematic diagrams of the various oscillographs on the market will disclose the fact that the power supplies in use are quite similar in operation, if not in fact. In general, two rectifiers are used. The half-wave rectifier usually supplies the Cathode-Ray tube alone (with the high potential grounded); while the full-wave rectifier supplies the amplifiers and other tubes and, for this reason, the filtering is much more extensive. Several types of filter systems are shown in Fig. 17A to Fig. 17D. The voltage-divider systems used in commercial practice are also quite similar. A careful study of Fig. 16 will show that the voltage

First, it is necessary to know how much plate and screen current each tube in the circuit requires, *at the voltage with which it is going to be used.* This information is readily obtainable from any tube manual.

Secondly, all the various currents required should be added together to give a total drain in milliamperes *without the bleeder current.* If the rectifier can safely supply the tube current, and still have a safety margin for bleeder purposes, then the total voltage-divider values may be calculated with plain arithmetic. A good point to remember is to use only four-fifths (or 80%) of the total current that the rectifier can safely supply, to obtain long tube life.

The beam-control system, in most oscillographs, consists of two potentiometers wired

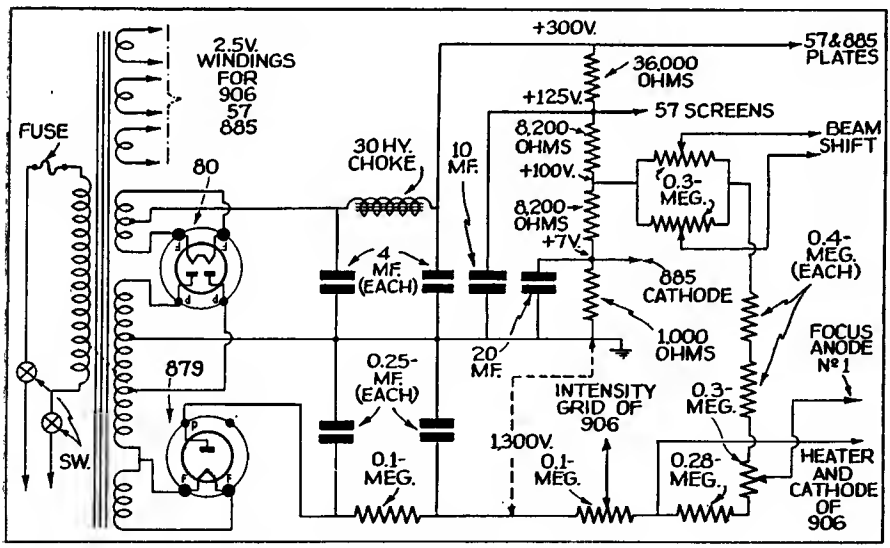


Fig. 16 Voltage Divider Circuit.

divider makes it possible to obtain fixed and variable voltages for the 906 grid, Anode No. 1 and beam-shifting voltages for the deflecting plates. Likewise, fixed operating voltages are obtained for plates, screens and the 885 cathode, from the low-voltage rectifier.

The principles involved in the calculation of the values required in any voltage-divider system will be briefly explained.

into the voltage-divider system in such a way that a plus, zero, or minus voltage can be applied to either deflecting plate, *neither of which draws any current.*

The RCA system in Fig. 20 enables the operator to apply on either plate a voltage, varying from plus 70 to minus 140; thus making it possible to locate the spot on the screen wherever desired. In the same voltage-divider system will be seen the "Inten-

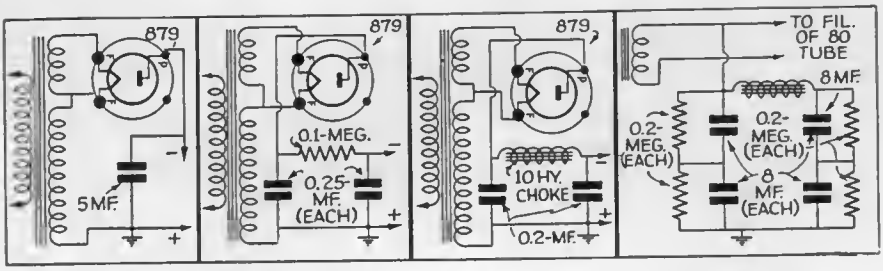


Fig. 17A Fig. 17B Fig. 17C Fig. 17D

sity" potentiometer, which controls the amount of negative voltage applied to the 906 grid. A range of approximately 100 volts, from 0 to —100, can be covered; which is sufficient to completely control the cathode-current beam.

The 'Focus' potentiometer is also part of the voltage divider and is used to control the size of the spot. By using the correct potential with reference to the fixed Anode No. 2 voltage, the spot can be brought down to the size of one sixty-fourth of an inch; which is sharply defined and clearly visible.

◆ ◆ ◆

Fig. 18.
RCA 3" Oscillograph

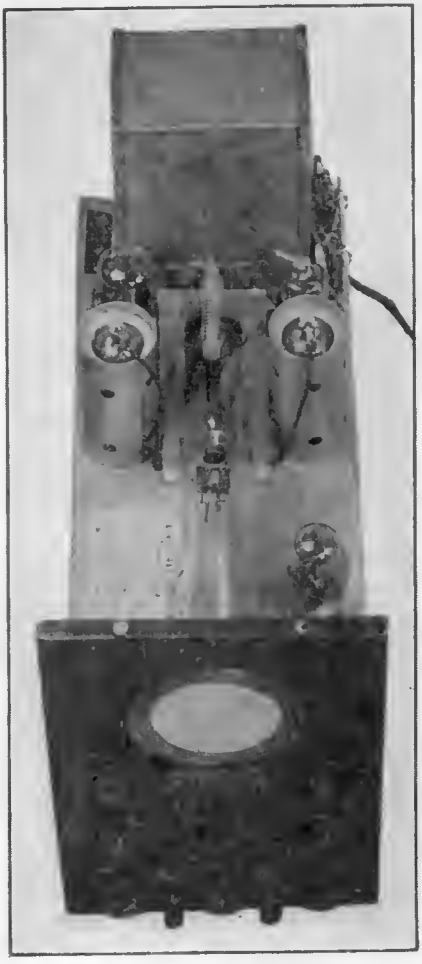


Fig. 19
RCA 3" Oscillograph with Cover Removed

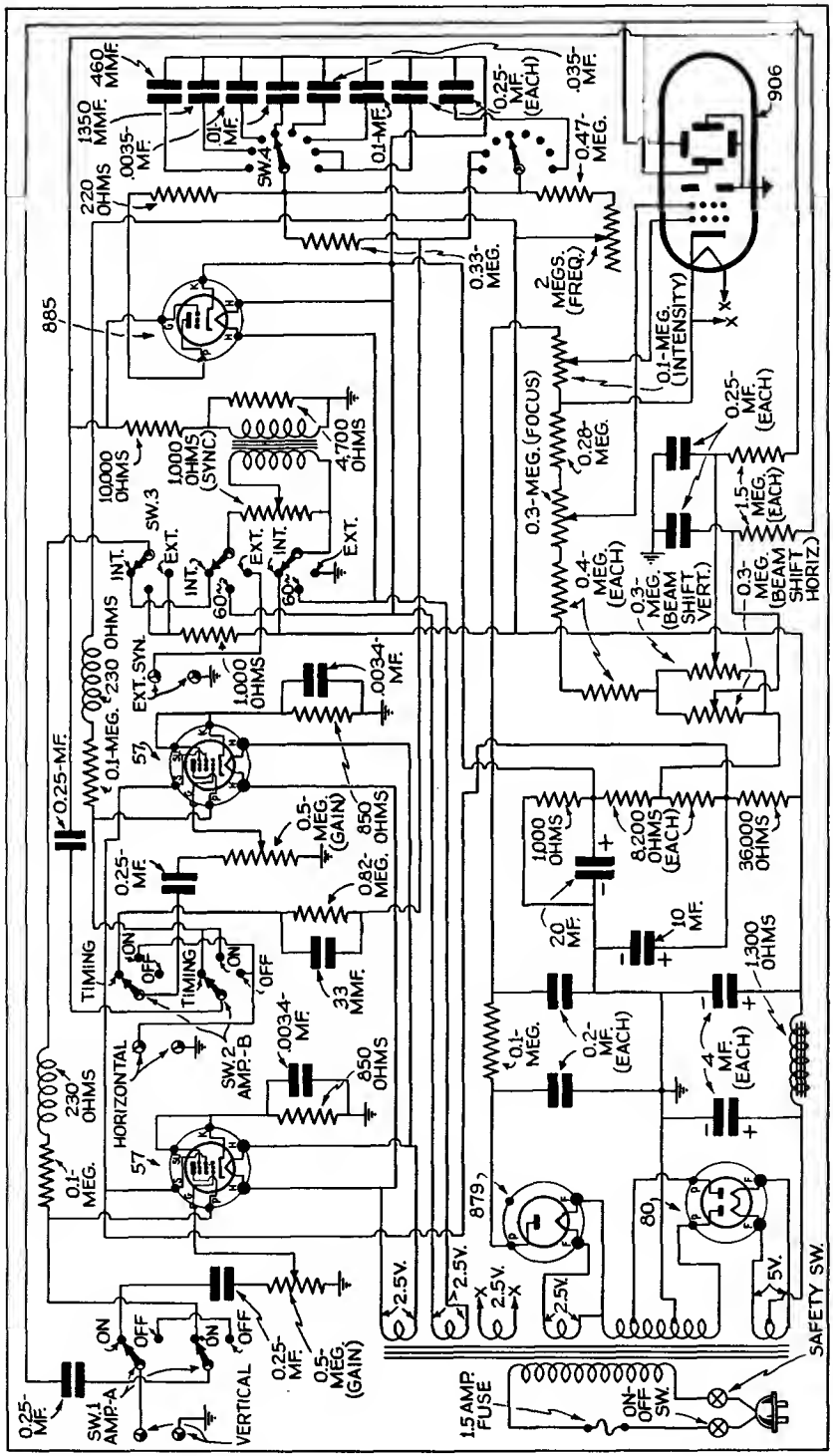


Fig. 20. RCA TMV—122B Oscillograph.

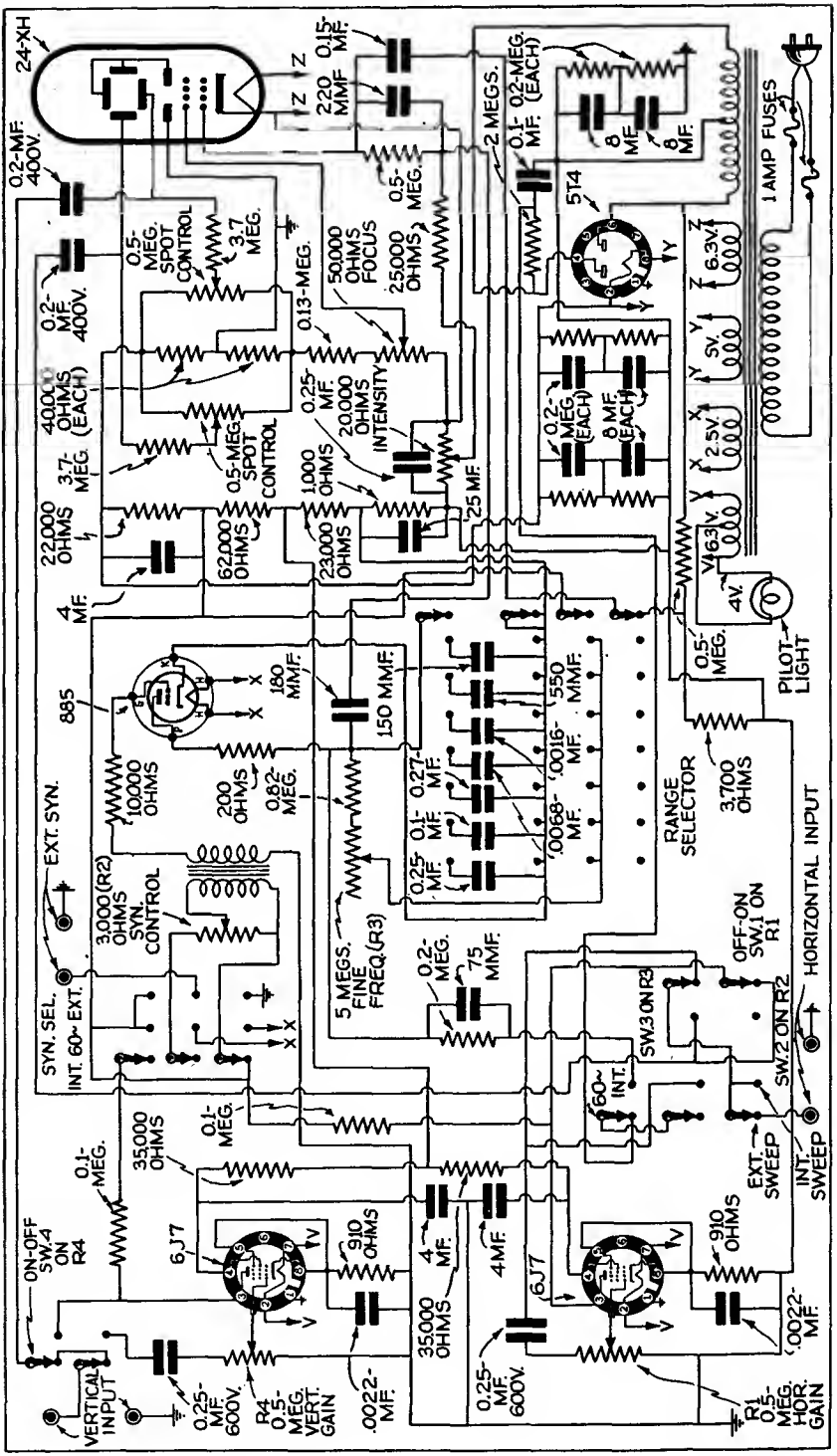


Fig. 21. Schematic of Model 535 Supreme 2".

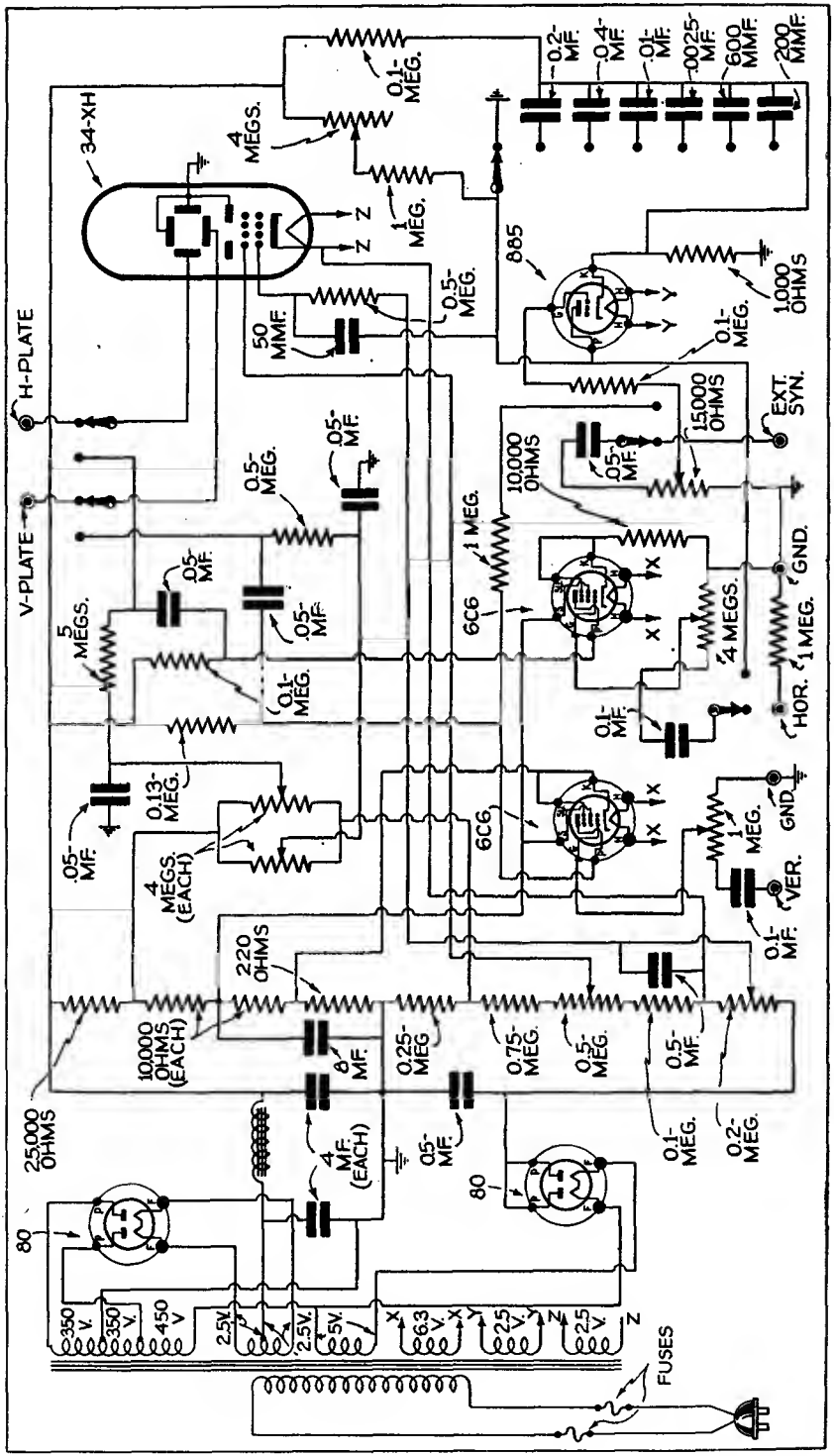


Fig. 22. Schematic of Model 546 Supreme 3"

CHAPTER 3

Sweep Circuits

An oscillograph without a sweep circuit is like a clock without hands. Since a clock without hands would be, obviously, useless for telling time, we may have carried the analogy too far; because the sweep-less oscillograph can still be used for several important measurements.

However, the addition of the "time-base," or sweep circuit, makes the instrument vastly more useful; and its principle should therefore be thoroughy understood.

The subject is so important that it fully warrants a detailed exposition from the very beginning. First of all, there are several *types* of sweep circuits, which include electronic, electrical, mechanical and magnetic types. In commercial practice the most widely-used type is electronic, employing a gaseous triode oscillator.

Returning to first principles, it is seen that a time-base is required only with varying voltages. A time-base used with a pure D. C. unvarying voltage on the vertical plate would produce a straight *horizontal* line. Without the time-base, this same voltage would appear as a motionless spot, somewhere on the screen.

Applying an alternating voltage on the vertical plate, without the sweep, would result in a vertical line; providing that the frequency of alternations was greater than 10 cycles per second. At very low frequency, the movement of the spot can be followed by the eye but, above 10 cycles per second, the motion of the spot itself cannot be followed and it appears as a line of light.

Now, in order to spread this alternating voltage across the screen, it is necessary to apply on the Horizontal plate a voltage which is equal in frequency and amplitude, but must be of the saw-tooth type of wave-form. Under these conditions, one complete cycle of the vertical voltage will appear to stand still on the screen. If the sweep-frequency is reduced to one half of the vertical voltage, then two complete cycles will appear on the screen. See Figs. 23A, 23B and 23C. This result can only be obtained with the saw-tooth wave form. This special form of wave is produced as follows:

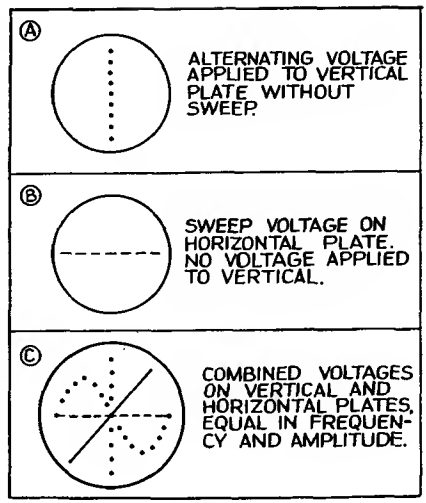

Ⓐ
ALTERNATING VOLTAGE APPLIED TO VERTICAL PLATE WITHOUT SWEEP.
Ⓑ
SWEEP VOLTAGE ON HORIZONTAL PLATE. NO VOLTAGE APPLIED TO VERTICAL.
Ⓒ
COMBINED VOLTAGES ON VERTICAL AND HORIZONTAL PLATES, EQUAL IN FREQUENCY AND AMPLITUDE.

Fig. 23A—B—C

The 885 tube is a grid-controlled, gaseous-discharge tube of the heater-cathode type. It is especially designed for use as a sweep-circuit oscillator in cathode-ray tube circuits.

Operation of the 885 as a sweep-circuit oscillator is made possible by the feature that a negative voltage on the grid either maintains plate-current cutoff, or promptly loses control; depending on the value of the plate voltage. After grid control is lost, it can be restored only by reducing the plate voltage below the ionization potential of the gas in the tube. This action can be controlled by means of a condenser, shunted across the plate circuit, which is charged through a current-limiting resistor.

When the voltage at the plate of the 885 reaches the break-down potential, the condenser discharges through the tube; the plate voltage drops, the grid resumes control and a new cycle is started.

A mechanical analogy may make the discussion clearer. We have all seen, at some time or other, how a pile driver operates. The hammer head is slowly pulled up to the top of its channel and then released, whereupon it falls several times faster than it ascended. In other words, it required 10

seconds of time to travel *up,* and only *one second* to travel *down.*

In the same way the voltage which is charging the condenser is also applied to the plate of the 885 at a *uniform rate of time,* and is also deflecting the spot *across the screen at the same time.* Now, when the condenser has been fully charged, the plate voltage rises to a maximum (on the plate). If this maximum voltage is enough to cause breakdown through ionization, then the condenser *instantly* discharges through the tube—and *also instantly snaps* the *spot* on the screen *back* to its starting point. A new cycle starts, and the action is repeated. Figs. 24A, 24B and 25C show a graphic view of the action.

In Fig. 24A, the capacity of condenser C determines the frequency at which the spot is moved across the screen. The variable resistor R is used for fine frequency adjustment.

from one of the filament windings of the power transformer within the oscillograph.

This voltage, of course, has the standard line frequency of 60 cycles. The 60-cycle sweep is applied to the horizontal deflection plates in place of the more widely used sawtooth type, in order to study and identify frequency ratios and the effects of phase shifting.

As we previously pointed out, when two *identical* alternating voltages are applied to both the vertical and horizontal plates, the resulting pattern is a single sloping line. When we say *identical,* we mean that the voltage, frequency and phase are all absolutely equal. The smallest change in any of these three quantities will cause the single sloping line to shift or change its form.

To illustrate, when the two voltages are *identical,* a straight sloping line will be

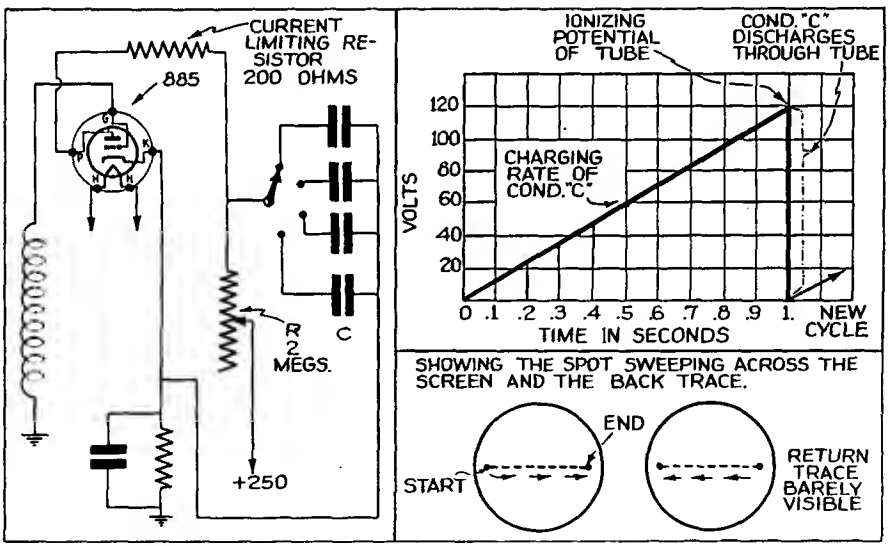


Fig. 24A **B—Above** **C—Below**

While Fig. 24B shows a linear charging rate for condenser C, this does not hold true in practice. Actually, the charging rate varies as the condenser approaches full charge, producing a bend at the top of the cycle. In practice, this bent part of the cycle is not used, only the linear portion being allowed to actuate the spot.

We will discuss now the applications of the 60-cycle sweep. As the name implies, this is an alternating voltage, usually obtained

traced from the upper left-hand corner of the screen, extending diagonally downward to the lower right-hand corner. Now, if these two voltages are equal in amplitude and frequency, but 180 degrees out of phase, you will see that the sloping line has changed its position from upper left to upper right, on the screen. This one test alone is of great help in observing symmetry of push-pull circuits, where equal *but opposite* voltages are required.

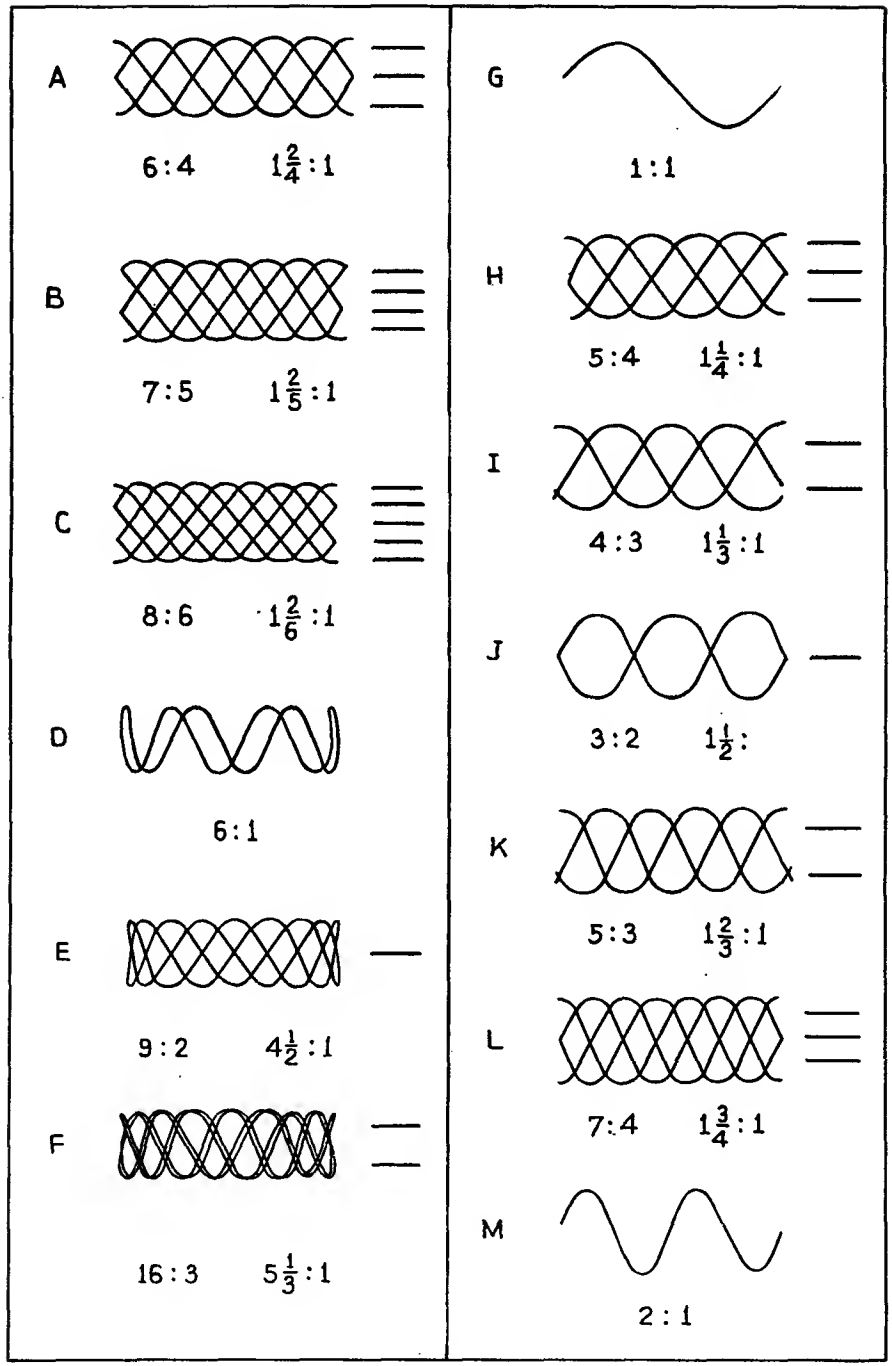


Fig. 25. Lissajou's Figures.

A further example is given: when two voltages are equal but 90 or 270 degrees out of phase, *a perfect circle* is seen on the screen. For all other degrees of phase shift, the image will be an ellipse, which gradually narrows down to a straight line at zero or 180 degrees.

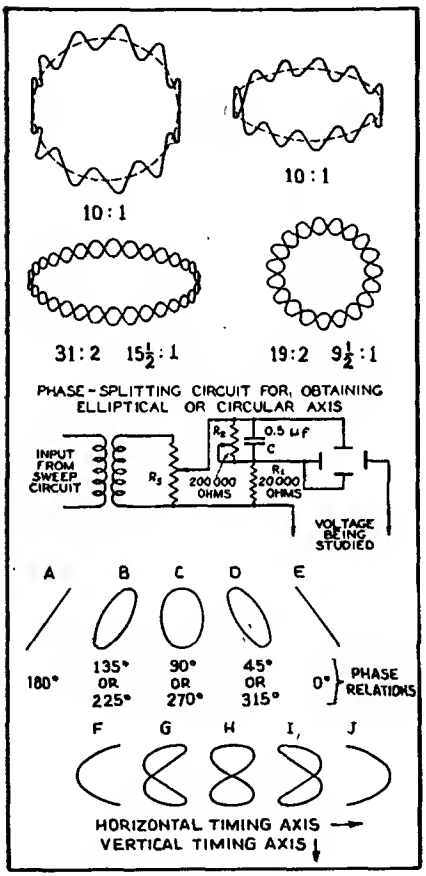


Fig. 26

All which has been said applies only to *equal* voltages or, to put it in another form, a voltage ratio of 1 to 1. Now, if one of these voltages is increased to just twice that of the other, an entirely different series of patterns is obtained. The outstanding pattern for the 2:1 ratio of voltage is the symmetrical figure "8," obtained when one voltage is exactly 90 or 270 degrees out of phase.

Successively higher frequency ratios give rise to complex patterns, which are known as *Lissajou's figures;* several types of these are shown in Fig. 25.

We wish to point out that the 60-cycle *sweep* should not be confused with the 60-cycle *pulse* which is built into most oscillographs. On the one hand, the 60-cycle sweep is used to spread the image across the screen; whereas the 60-cycle pulse is used to modulate the grid of the *saw-tooth oscillator,* so that it is possible to lock the frequency of the saw-tooth oscillator to 60 cycles, or any of its multiples up to about the tenth harmonic (600 cycles).

External sweeps can be connected to most oscillographs by means of the connections provided. They may be of any form, including the mechanical types; and in Fig. 27 such a type is shown.

With this arrangement, the potentiometer arm revolves completely around the periphery of the circle, gradually increasing from minus to plus. When the arm reaches the extreme end of the plus side, the contact is broken momentarily; and the arm then touches the minus side, thus starting a new cycle. A mechanical sweep such as this could be used in the study of heart action, for one example.

◆ ◆ ◆

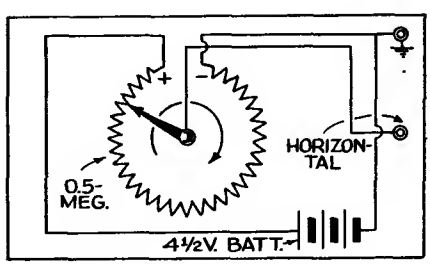


Fig. 27. Mechanical Sweep Circuit

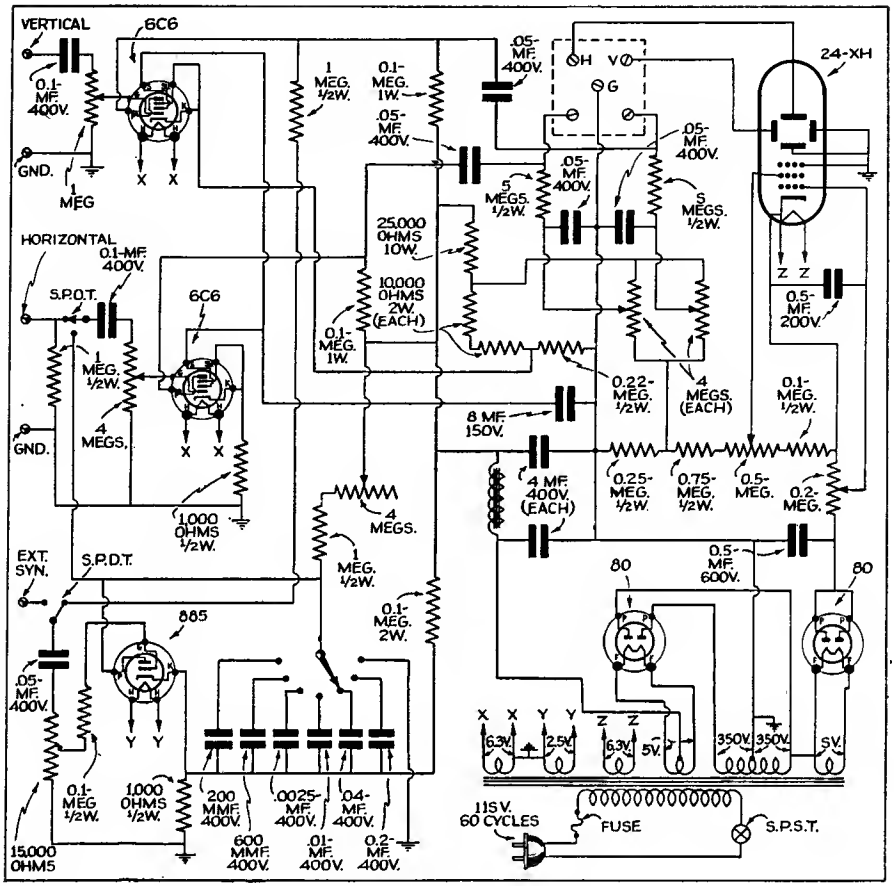


Fig. 28. Dumont 2" Oscillograph

Fig. 29.
Dumont 3"
Oscillograph
Model 148

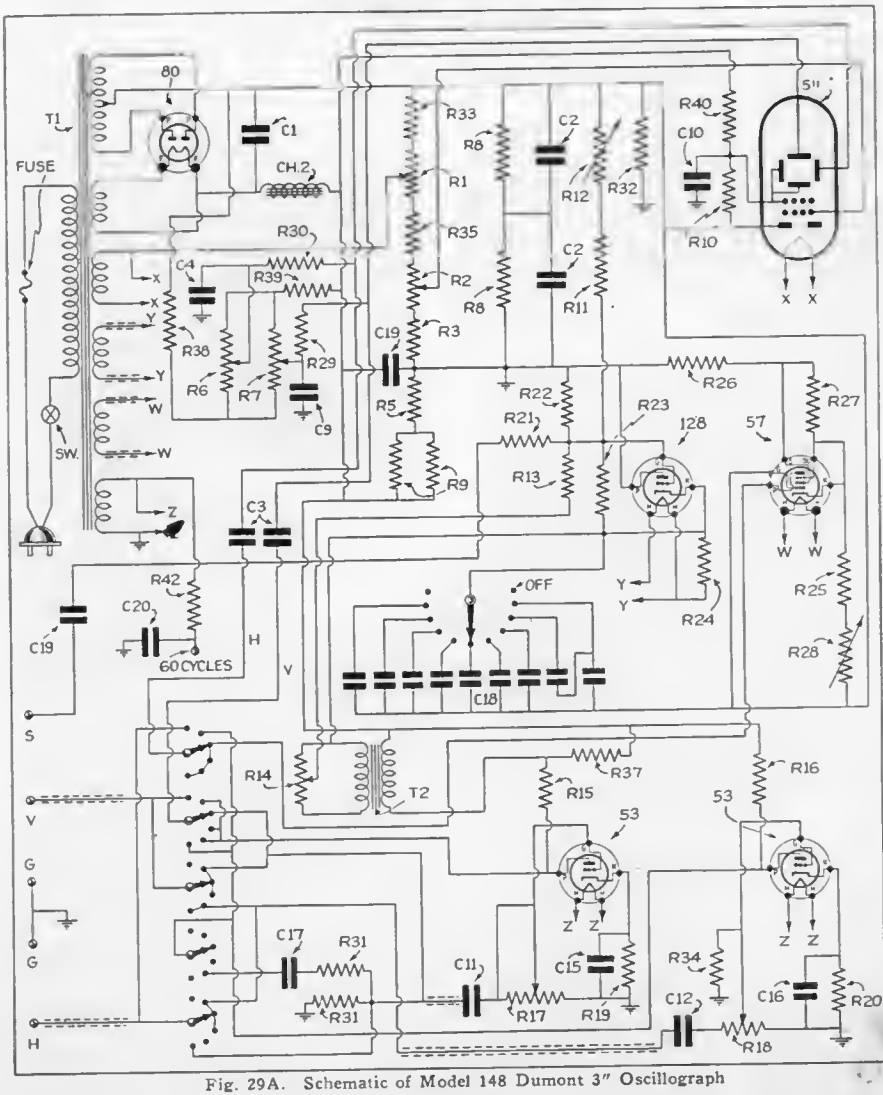


Fig. 29A. Schematic of Model 148 Dumont 3" Oscillograph

CHAPTER 4

Operation of a Typical Unit

The operating instructions given here can be applied in general to any unit on the market, and should be followed closely only when no instruction book is available for the particular instrument being used.

First of all, be very sure of the type of current in use at the location where it is desired to use the oscillograph. Unless specially built, all oscillographs are made for the standard 110-volt 60-cycle current.

Plug the unit into the line, and wait about a minute for all the tubes to warm up. Look at the viewing screen; if the spot is invisible or very dim, turn up the "Intensity" control gradually until the spot is about one sixty-fourth of an inch across and easily seen, but not too bright or glaring. If the spot has a halo around it, turn the "Focus" control gradually until the halo disappears and the spot is sharp and clear. (We are assuming, of course, that no connections have been made to the deflectors meanwhile.)

The spot position should, normally, be in the exact center of the screen. If it is not, then the "Beam-shift" controls should be adjusted to give the correct position. In special cases (such as when aligning by the visual-resonance curve method) it is necessary to shift the beam downward, so that the top of the resonance curve is within the limits of the screen.

Now the unit is ready for use, except that the sweep oscillator and its amplifiers should be switched into circuit. If everything has been correct so far, a straight line should extend across the screen. The length of this line is controlled by the "Horizontal Amplifier Gain" control, and should be adjusted so that the line does not touch the ends of the screen.

For most measurements, the "Rough" sweep-frequency range switch should be set to less than 100 cycles, and the "Fine" sweep adjustment can then be varied to suit.

A large percentage of all measuring is done by using the vertical deflector as the input source, while the horizontal deflector is in use with the sweep voltage.

After connecting the vertical deflector to the voltage under test, it will generally be noticed that the image is dimmer than the previous straight line without signal. This is perfectly normal; and the brilliancy of the pattern may be increased to the proper level by turning the "Intensity" control up a little.

The synchronizing control is then brought into play; when properly adjusted, this makes the image stand still on the screen. When it is not adjusted, the image moves continually across the screen, sometimes in one direction and sometimes in another.

The circuit behind this control consists of a means whereby a small part of the vertical voltage is applied to the grid of the saw-tooth oscillator, which has the commendable quality of falling into step with any voltage applied to it. The result is that the vertical and saw-tooth voltages start together, at the same instant, and complete their cycles together, thus producing a standing image.

As we mentioned in a previous chapter, the chemical coating on the screen of the Cathode-Ray tube becomes fluorescent whenever electrons strike the surface of the screen with *sufficient* impact. If the spot is not in motion, the impact or intensity of the beam may be great enough to burn out the chemical coating on the screen, at the point of impact.

The effect is analogous to holding a lens, focused to a pin-point in strong sunlight, over a piece of paper. In a few moments the paper will begin to smolder and burn where the pin-point of light strikes it.

Now, if the same pinpoint of light is set in motion, the paper will not burn; because the concentrated energy of heat is distributed over a large area. This same action goes on in all Cathode-Ray tubes, and explains why the tube manufacturers caution the user to *keep the spot in motion* or else to make it very dim.

Caution should be observed, even when the spot *is* in motion, to keep the beam intensity just high enough to be plainly visible—no more—to prolong the screen's life.

VERTICAL AND HORIZONTAL AMPLIFIERS

Amplifiers are used, in all oscillographs, solely for the purpose of increasing the deflection sensitivity of the spot. Without the aid of an amplifier, the RCA 906 3-inch tube, for instance, requires an input voltage of 75 to move the spot one inch. With the amplifier switched in, only 2 volts are required to obtain the same one-inch deflection. As can be seen, the deflection sensitivity has been increased approximately 38 times through the use of the amplifier. Still greater sensitivity can be obtained by adding another amplifier stage.

The vertical and horizontal amplifiers as used in most of the commercial instruments, consist of specialized forms of the resistance-capacity coupled type. This type has been found to be the best suited for oscillograph purposes in the matter of good stability, high gain, and very wide and uniform frequency response. A study of the various schematics will show that, while different makes vary in appearance, basically they are all related.

In general, these amplifiers must be capable of passing a frequency range, from 10 cycles up to about 90,000 cycles, at uniform gain and without introducing any distortion of their own. In the majority of cases, one

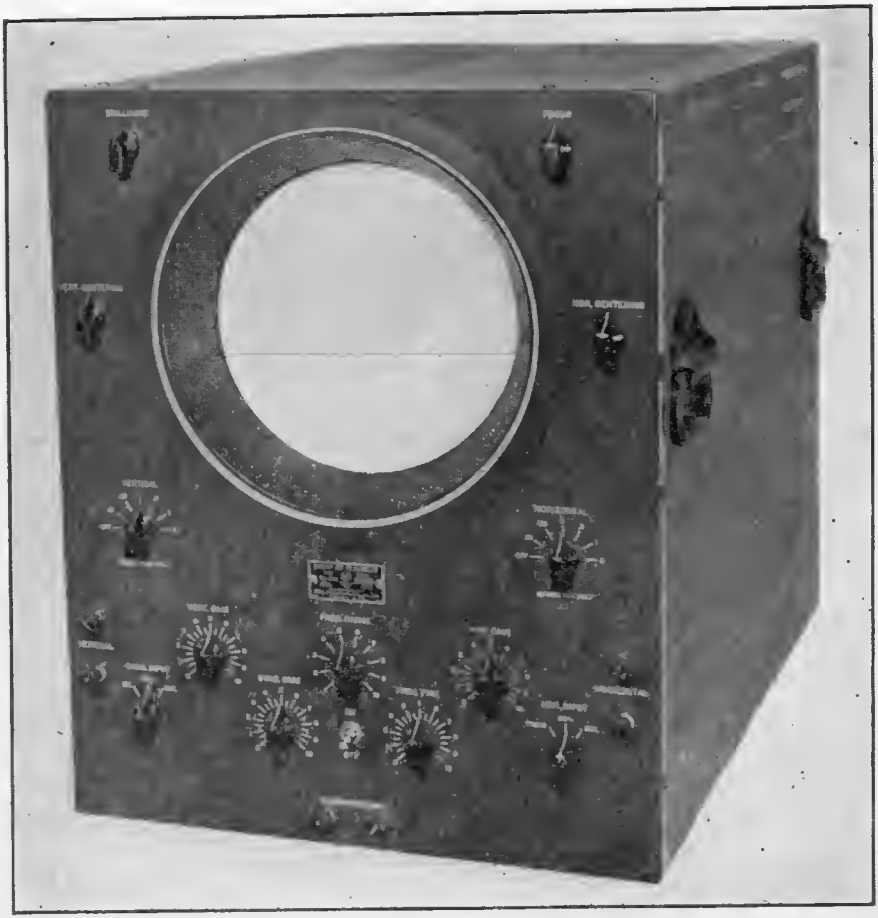


Fig. 30. RCA 9" Oscillograph Model TMV—168A

stage of amplification for each deflector is all that is required. However, the larger instruments, such as the 9-inch oscillographs, require two or three stages; because of the extra voltage-gain required to move the spot the full screen distance.

An outstanding example of excellent design is shown, in the schematic of the RCA TMV-168A, 9-inch oscillograph. Push-pull amplifiers, used for both the vertical and horizontal deflector plates, have a frequency response extending from 4 cycles up to 300,000 cycles per second.

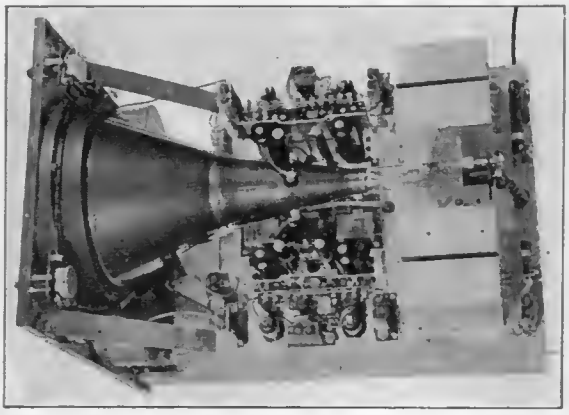


Fig. 31.

Interior View of 9" RCA Oscillograph—Schematic on Page 25

For those constructors who like to build their own instruments,, and also want them to have a professional appearance, we are reprinting the instruction sheet of the Thordarson Oscilloscope which uses the 1-inch Cathode-Ray tube in conjunction with a lens; giving the equivalent of a 2-inch image.

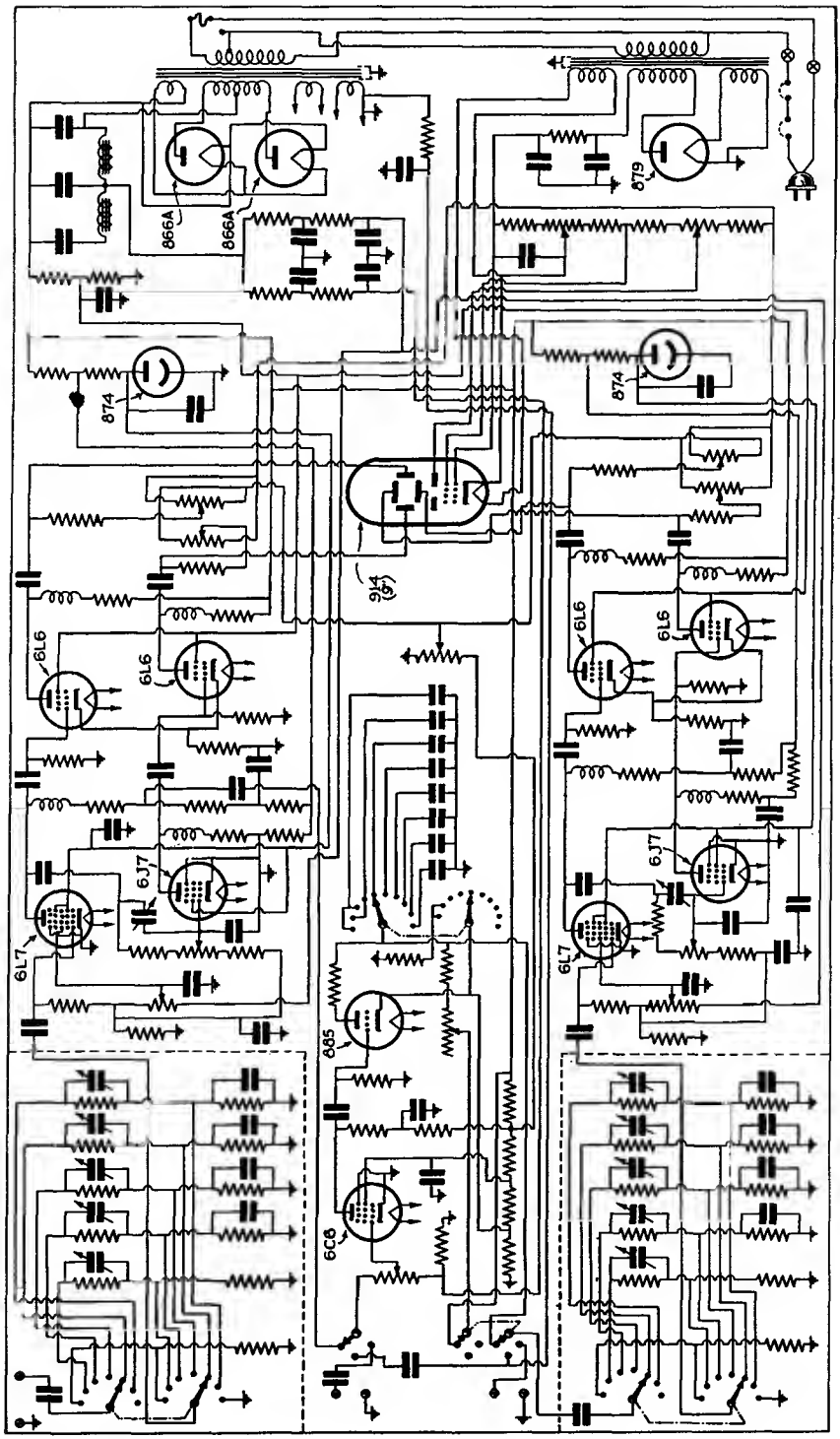


Fig. 32. Schematic of RCA 9″ Oscillograph TMV 168A.

INSTRUCTION SHEET FOR ASSEMBLY AND OPERATION OF THE THORDARSON T11K16 OSCILLOSCOPE.

The coming of the Cathode-Ray tube to the field of radio has been likened to the advent of the X-ray into the field of medicine. It brought an entirely new technique of diagnosis into being. It has made visible the heretofore hidden processes of radio. Again, as with the X-ray, considerable time has elapsed between its inception and its general understanding and use.

Fundamentally, an oscilloscope is a voltmeter or milliammeter with the time element added. In other words, the reaction of a circuit under test can be determined at each and every instant of any desired period of time.

Since most radio phenomena occur and reoccur in cycles, or repeated operations, and since they repeat these cycles at a speed beyond that required to overcome the well-known laws of visual persistance, a single image is seen on the screen of the oscilloscope.

Two different "sweeps," or comparisons with time, are found on the efficient oscilloscope. The simplest is at the rate of 60 cycles per second, and is obtained by applying an A. C. voltage to one set of deflector plates, usually the horizontal.

The second is called *linear* sweep. This is the so-called "saw-tooth" sweep, which rises to a maximum and drops abruptly to zero, over a wide range of frequencies per second.

The time element to be studied must be an exact multiple of the sweep, or standard time element. Thus, the 60-cycle sweep is limited in its use, but is invaluable for an analysis of hum.

On the other hand, the linear, or saw-tooth, sweep covers a band of from 20 to 12,000 cycles per second. With the aid of a vernier control, the frequency can be controlled to within one cycle. Exact synchronism with the signal under test is possible.

This range, 20 to 12,000 cycles, covers practically all of the audible range, permitting synchronisms with, or viewing of, any single frequency desired. This is the method used in a study of wave-form or distortion.

When this fundamental conception is understood, numerous uses immediately present themselves.

1. Measuring the percentage modulation of a transmitter.
2. Analyze and locate hum. By moving the pickup connection to different stages of the unit under test, the source of the hum will be shown.
3. Audio distortion in either the transmitter speech equipment or the receiver.
4. Alignment of receivers with high fidelity A. F., R. F., and I. F. sections.

The 913 oscilloscope kit has been so designed as to enable anyone to build a professional oscilloscope in every detail. The placement of parts has been carefully planned for a compact, yet highly efficient layout. Carefully following these instructions will insure success for every builder.

Brands and trade names specified in the parts list were used in the original laboratory model. Parts of equivalent quality may be substituted except where physical limitations prohibit.

Wiring and construction should be divided into three parts. First, the wiring of the front panel controls; next the wiring of the chassis; and, third, the combining of the two and final wiring.

THE FRONT PANEL

If etched panel No. T-11K17 is to be used, mount it before controls are attached. It is held in place by the control nuts.

Mount the controls as shown in Fig. 33, or in the following positions as seen from the front:

R13, intensity control, at the upper left.

R12, the focus control, to the right of R13.

R10, horizontal centering, at the upper right.

R11, vertical centering, to the left of R10.

On the bottom, ranging from left to right, are: R2, horizontal amplifier; R1, vertical amplifier; S3, sweep-frequency switch; R14, sweep vernier; and R22, sweep lock control.

Mount S1 at the left of the lens opening, and S2 at the right, in the two holes still left.

Mount all controls with terminals pointing up. Mount S3 with the blank terminals at bottom. See Fig. 33.

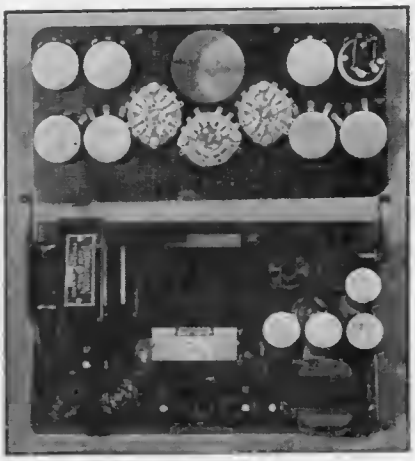


Fig. 33.

Before mounting the switch, make sure that the stops are in the correct position to give the right number of switch contacts. S1 should have only two positions, S2 should have three and S3 five.

Solder leads to all the terminals and wire the front panel as follows before mounting it on the chassis.

Leave the loose ends of all wires pointing toward the 913 screen opening, as shown in Fig. 34. Connect "L" terminal of R1, as shown in Fig. 33, to the corresponding terminal of R2, and attach a lead of insulated wire about 8" long for grounding later. Solder 6" leads to the "C" terminals of both R1 and R2, which will go to the grid caps of the 6J7. Connect the "R" terminal of R1 to the bottom switch terminal, No. 7 of S1, and the "R" terminal of R2 to the bottom terminal No. 6 of S2.

Wire R10 and R11 in parallel, with "L" terminals together and "R" terminals together. Attach 12" leads to "L" and "R" terminals on R10. Solder 18" leads to the "C" terminals of R10. Solder 18" leads to the "C" terminals of R10 and R11. These four leads may now be cabled together for a distance of about 4".

Joint the "R" terminal of R13 and the "L" terminal of R12 and attach an 18" lead to the "L" terminal of R12. Solder 18" leads to the "C" terminals of R12 and R13, one about 14" long to the "R" terminal of R12, and an 18" lead to the "L" terminal of R13. These five leads may also be cabled for about 4", to go later through the hole and grommet under S1, Fig. 34.

Solder a 4" lead to the "L" terminal of R22; this will be grounded later to the bottom input near it. Solder a 10" lead to the "C" terminal of R22. Connect the "R" terminal of R22 to the top common, No. 12 of S1.

Solder a 14" lead to the "C" terminal of R14 and a 12" lead to the "R" terminal. The "L" terminal is not used.

Make the following connections on S1. Insulate one end of C1 with a piece of spaghetti and solder to terminal No. 12. Leave the other end of C1 loose at present. Solder an 8" lead to terminal No. 1. Connect a jumper between terminals No. 2 and No. 8 Solder a 9" shielded wire to terminal No. 6. This lead will later go straight back to the 913 tube, along the top of the chassis, as shown in Fig. 34.

Insulate one end of C4 with spaghetti and solder to terminal No. 12 of S2. Join terminals No. 3 and No. 7, solder a 20" lead to terminal No. 2 and an 8" lead to terminal No. 1. Terminals No. 8 and 9 are not used.

Solder a 16" lead to the common terminal, No. 7 of S3. Solder 6" leads to No. 1, 2, 3, 4 and 5 terminals.

Mount the sockets as follows:

The 1-V, V3, with filament prongs toward the front panel: the 6X5, V4, with slot toward the front: the 6J7's, VI and V2, with slots toward the front; the 885, V5, with heater prongs nearest the front.

Mount the power transformer, T-1, the choke, Ch-1, and the electrolytic condensers, C7, C8, C9 and C10 as shown in Fig. 33.

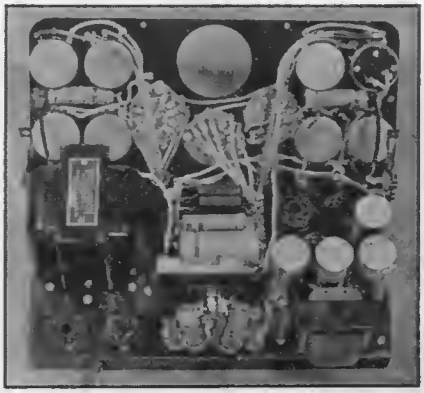


Fig. 34.

The black primary leads of the power transformer should come out at the hole nearest the edge of the chassis.

Mount C11, the paper electrolytic condenser, with positive terminal toward C7.

Mount the 913 socket in its bracket, with terminals No. 2 and 7 toward the bottom on the angle side. Mount the four sets of 5-lug resistor mounts under and on top of the chassis, as shown in Fig. 34 and 35. Mount the 913 bracket at the rear of the chassis as shown in Fig. 33. (Note: the screws used for the resistor mounting strip on the rear of the 913 bracket, with the mounting holes toward the top. Bend the center lug under or cut it off.)

Cut the tenth resistor strip, so that two solder terminals are left on one end. Mount this under the choke mounting screw at the end of C12 as shown in Fig. 35.

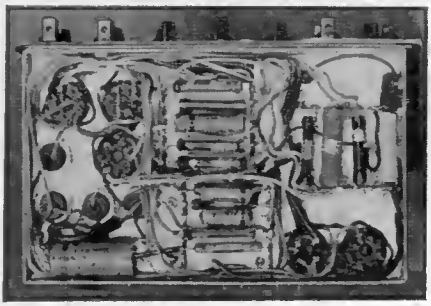


Fig. 35

Insert rubber grommets in the four holes in chassis, as shown in Fig. 34.

The chassis is not to be used as a ground, although it is at ground potential.

For a ground, use a No. 14 tinned copper wire. Solder one end of the wire to terminals 5, 7 and 9 on the mounting strip, Fig. 35; make a 90 degree bend so the wire points toward C9; make another right-angle bend at the edge of the chassis, running the wire to the end of C12, where it is bent down and solder anchored to the mounting-strip screw. Solder a short piece of bus bar from the machine screw, near No. 9 lug on the resistor strip, to the common ground. This screw is used for a ground on the top of the chassis.

Mount all the resistors and condensers on the mounting strips as shown in Fig. 35.

Note: C3 and R4 have their common leads soldered at No. 9 and 10; R15 and C18 at point No. 18.

Connect terminal 1 of socket V3 to terminal 2 of the 913 socket, V6. Connect terminal 4 of V3, to terminal 7 of socket V6. Connect the yellow leads to terminals 1 and 4 of socket V3.

Join the No. 2 terminals of V1 and V2. Join the No. 7 terminals of V1 and V2. Connect the blue leads of T1 to terminals 2 and 7 of V1.

Solder the green leads of T1 to terminals 2 and 7 of V4.

Connect the brown leads of T1 to terminals 1 and 5 of V5. Cut off and tape the white lead of T1, which is not used. Solder the red and white lead of T1 to the bus bar ground.

Solder the red leads of T1 to terminals 3 and 5 of V4; then connect terminal 5 of V4, to terminal 3 of V3.

Solder the black leads of C7, C8, C10 and the red lead of C9 to the bus-bar ground. Solder one lead of C12 to No. 2 resistor lug, insulating it with spaghetti, and the other end of C12 to No. 1 terminal of the corner resistor strip.

Connect the red lead from Ch-1, to the cathode, terminal 8 of V4. Solder the red lead of C7 to this same point. Connect the black lead of Ch-1 to point on the resistor strip. Join 11, 13 and 26 on the resistor strips. Connect the red lead of C8 to No. 11.

Join points 1 and 3. Connect this point, No. 3, to the plate, terminal 2 of V5. Join No. 15 and No. 21 on the resistor strip. Connect the grid, terminal 3, of V5 to point 15. Join No. 28 and 30, then run a lead from this point to the cathode, terminal 4 of V5.

Join the ends nearest T1 of C13, C14, C15, C16 and C17, and connect to the positive terminal of C11. Run a lead from the positive terminal of C11 through the rubber grommet to terminal 4 of V5, and extend to points 28 and 30 of the resistor strip. Solder the negative of C11 to the screw previously mentioned as a ground. Connect the black lead of C9 to the end lug of the short resistor strip; and the anode, terminal 2, of V3 to the same point. Ground the shell, terminal 1, of V4 to the bus bar.

Run a lead from point 14 to the plate, terminal 3, of V2 and from point 12 to the plate, terminal 3, of V1.

Join points 6 and 4 together and connect to terminals 8 and 5 of V1. Connect point 10 of the resistor strip to terminals 8 and 5 of V2. Join the number 4 resistors of V1 and V2. Joint the number 4 terminals of V1 and V2, and extend the lead to points

25 and 27 of the resistor strip. Connect the red leads of C10 to No. 4 terminal of V2. Join terminals 1 and 7 of V2 to terminal 1 of V1 and ground the lead to the bus bar.

Turn the chassis over. Fasten on the two side brackets. Mount the four input jacks. Use two fibre washers to insulate the top jacks, one on each side of the bracket, and none on the bottom jacks. Bend the solder lugs upward, so they will clear the tubes, etc. Ground each lower pin jack to the grounded screw at the end of C13 near the power transformer, as shown in Fig. 34.

Connect C6 between terminal 4 of the 913 socket and the second resistor lug from the left, as shown in Fig. 36. Connect R7 between terminal 4 of the 913 and the first solder lug. Connect C5 between terminal 6 of V6 and the second solder lug from the right and R8 between terminal 6 and the first solder terminal. Ground terminal 1 of V6 to the bus bar.

FINAL ASSEMBLY AND WIRING

Assemble the front panel to the chassis; pushing all the left hand leads through the grommet under S2, and the right hand leads through under S1 as shown in Fig. 34. These leads must be pushed through before the front panel is fastened to the chassis.

Connect C13 to terminal 5 of S3, C14 to 4, C15 to 3, C16 to 2 and C17 to 1. Connect the common terminal, No. 7 of S3, to point 2 on the resistor strip, underneath the chassis.

Connect the shielded lead from terminal No. 6 of S1 to the end of C5 on the resistor strip V6, Fig. 34. Ground the shield to the screw that holds the bracket.

Connect the free end of C1 to the top pin jack nearest it, and do likewise for C4, insulating the leads with spaghetti as shown in Fig. 34.

Solder the grid-cap terminals to the two leads from the center "C" of R1 and R2. Solder the lead from the "L" terminals of R1 and R2 to the nearest bottom pin jack.

Solder the lead from "C" of R12 to terminal 3 of V6, and the one from "C" of R13 to terminal 5. Solder the lead from "L" of R12 and "R" of R13 to terminal 7 of V6. Solder the lead from "R" of R12 to point 20 of the resistor strip and the "L" lead of R13 to the end lug of the short terminal strip. Solder the lead from terminal 1 of S1 to the plate, terminal 3, of V1. Connect terminal No. 1 of S2 to terminal 2 of V1, and terminal No. 2 to the first lug of the terminal strip at the end of C12.

Solder the lead from the "L" terminals of R10 and R11 to point 25-27 on the resistor strip. Connect the lead from "C" of R10 to the resistor-strip end of R7 and the "C" of R11 to the resistor-strip end of R8. Solder the "R" leads of R10 and R11 to point 19 on the resistor strip.

Connect point 14 of the resistor strip to the bottom end of C6. Solder the "C" lead of R14 to point 4 of the resistor strip, and the "C" lead of R22 to point 17. Ground the 4" lead on "L" R22 to bottom input jack nearest it.

Ground the tap on R19 to point 29 and extend the lead to the bus bar at point 9.

Pull the end of the A. C. cord through the grommet in the back of the chassis, about 10", knot it. Run a twisted pair from the switch point on R13 down the side and across, through the hole under S3 as shown in Fig. 34. Solder one of the switch leads to one of the A. C. line leads and the other to one of the black leads of T1. Connect the other A. C. line lead to the remaining back lead of T1.

Ground point 22 of the resistor strip at point 9.

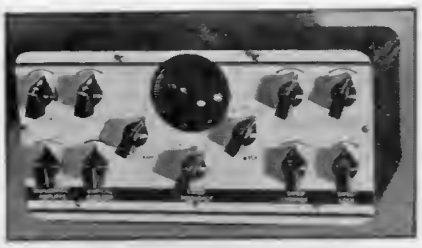


Fig. 36

TESTING

Place tubes in the proper sockets and fasten the 913 light shield to panel with clamp. Insert the A. C. plug in the 115-volt 60-cycle receptacle. Turn R13 up about halfway. As soon as the tubes have heated, a green spot should show on the screen. If S2 is in the middle or "linear" position, this spot should become a straight line. (This is without any outside connection). If the line is not in the correct plane, turn the tube to correct it. The length of the line should be increased by turning R2 to

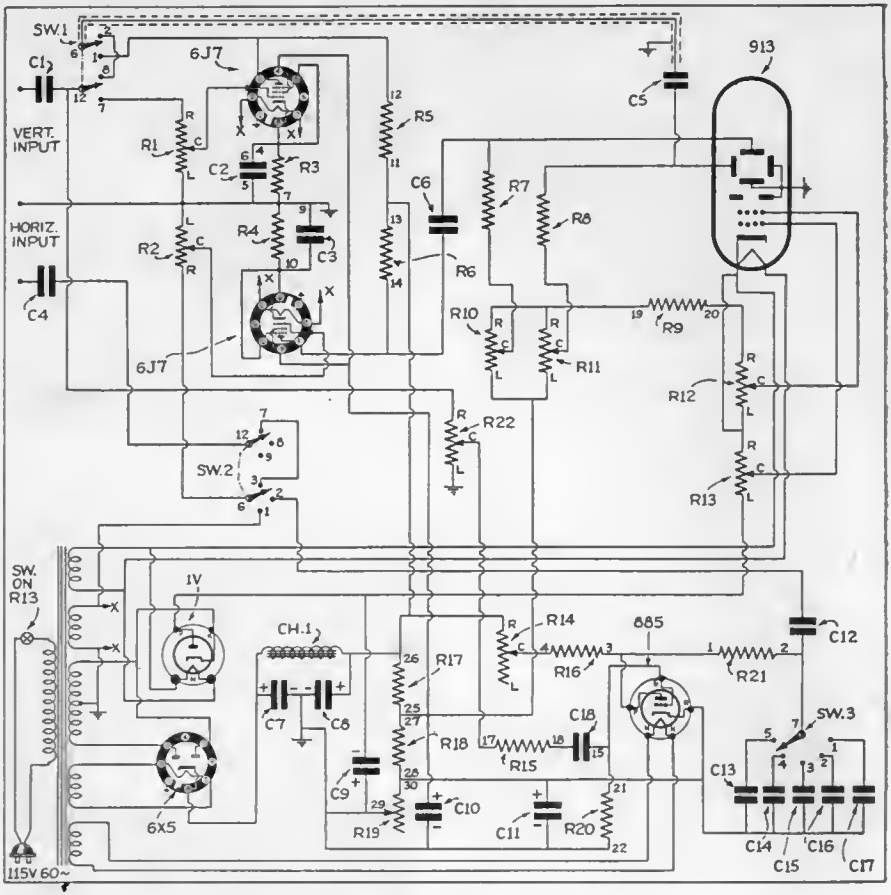


Fig. 37 Schematic of Thordarson Oscilloscope

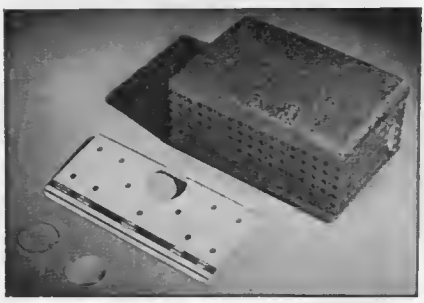


Fig. 38

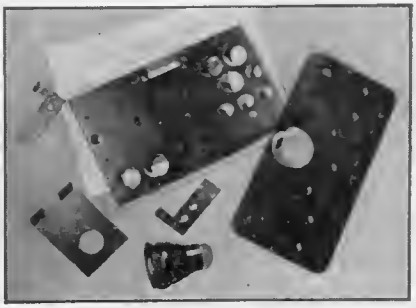


Fig. 39

the right and clockwise. R11 should shift it up and down, R10 to the right or left.

Next turn S2 to "60 cycle" sweep. A straight line should still extend across the screen. Turning S2 to "external" should produce just a spot, not a straight line.

To put the correct bias on the 885 tube, and thus insure proper frequency generation, apply from 2½ to 6 volts A. C. from a filament transformer to the left-hand set of input jacks, or vertical amplifier. With the sweep-frequency switch, S3, in the extreme left-hand position, and the sweep vernier also in the extreme left-hand or counter-clockwise position, adjust the slider on R19 until three cycles appear on the screen. This indicates that the 20-cycle sweep is synchronized with the 60 cycle A. C. and is now correctly adjusted. The slider can be tightened and left in this position.

The input jacks near the amplifier tubes, V1 and V2, are for the vertical amplifier and should be used to couple the oscilloscope to the unit under test.

When an audio signal is coupled to the "scope" from an audio oscillator, or from the output of a set which has a single-signal-modulated R. F. wave passing through it, adjust the sweep frequency S3, to synchronize as nearly as possibly with the applied signal. Use the vernier sweep to produce exact synchronism, and the sweep lock to fix the image on the screen. The size of the image is regulated by the vertical and horizontal amplifier controls R1 and R2.

MOUNTING LENS

Fit lens into front of light shield and retaining ring into recess in front of lens.

ATTACHING COVER

Fasten short bracket, included in foundation kit, to chassis, using 6/32" screw, immediately under S3. Push chassis into cover so that panel fits to top brackets of cover. Make sure the side brackets of cover are between the two chassis side brackets and the front panel, and the bottom chassis bracket is inside cover. Fasten front panel to tapped brackets with 6/32" screws.

THORDARSON OSCILLOSCOPE PARTS LIST

THORDARSON FOUNDATION UNIT AND ACCESSORIES

1 Foundation Unit, T11K16, consisting of chassis, panel, 913 shield and instruction sheet .....
1 Etched panel, T111K17 .....
1 Cover, T-11K19 for foundation unit
1 2" Lens with retainer ring (optional) T-11K20.

THORDARSON TRANSFORMERS AND CHOKES

1 T-9233 Power Transformer ..
1 T-7430 choke .....

913 CATHODE-RAY OSCILLOSCOPE CONTROLS

Numbers	Ohms	Type
R-1	500,000	Potentiometer
R-22	500,000	"
R-2	1,000,000	"
R-10	100,000	"
R-11	100,000	"
R-12	50,000	"
R-13	25,000	" with switch
R-14	3,000,000	"
S-1	2 pole, 2 position switch	
S-2	2 pole, 3 "	"
S-3	1 pole, 5 "	"

RESISTORS

Number	Ohms	Watts
R-3	5,000	1
R-4	5,000	1
R-20	5,000	1
R-5	500,000	1
R-6	500,000	1
R-7	2,000,000	1
R-8	2,000,000	1
R-9	75,000	1
R-15	50,000	1
R-16	750,000	1
R-16	750,000	1
R-17	40,000	20
R-18	8,000	1
R-19	800	1
R-21	200	1

CONDENSERS

Number	Mfs	Voltage
C-1	.1	400
C-4	.1	400
C-5	.1	400
C-6	.1	400
C-8	.1	400
C-2	.003	200
C-3	.003	200
C-7	8	525 Electrolytic
C-8	8	525 "
C-9	8	525 "
C-10	8	250 "
C-11	25	25 "
C-12	.5	400
C-13	.5	400
C-14	.13	400
C-15	.04	400
C-16	.007	400
C-17	.0014	400

TUBES

1 Type 913 Tube
1 Type 1-V Tube
2 Type 6J7 Tubes
1 Type 885 Tube
1 Type 6X5 Tube

MISCELLANEOUS PARTS

2 Metal tube grid caps
1 4-prong socket (for 1-V tube)
1 5-prong socket (for 885 tube)
4 Octal sockets (for 2-6J7, 6X5, 913 tubes)
11 1¼" bar knobs
9 5-lug resistor mounting strips
1 2-lug resistor mounting strip
24 ⅜" 6/32 nuts, screws and lockwashers
1 A. C. line cord and plug
4 Pin jacks
3 ⅜" Grommets
1 ¼" Grommet

◆ ◆ ◆

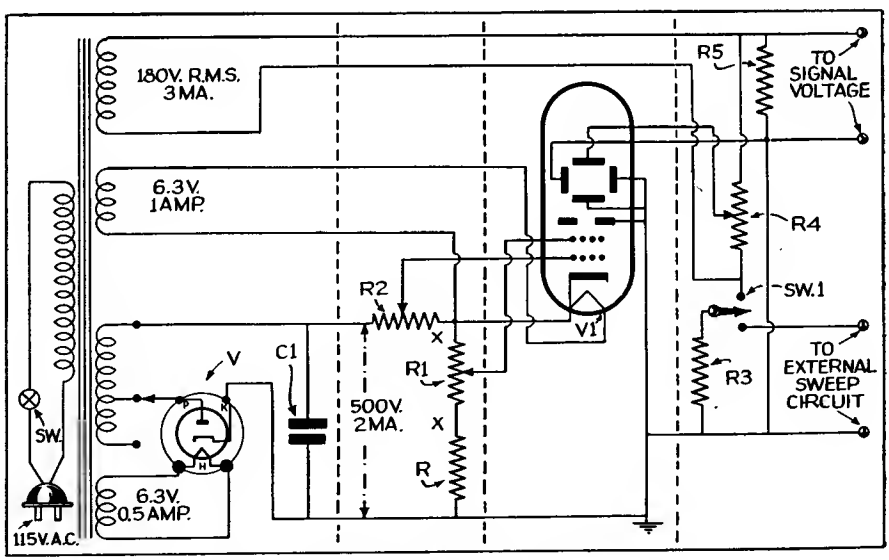


Fig. 40. Schematic of Kenyon 913 Oscilloscope.

CHAPTER 5

Methods of Measurement

The oscillograph is essentially an indicating device, which can perform the function of voltmeter, ammeter, ohmmeter, capacity meter and, in bridge circuits, as a null indicator. While it is true that some of the above functions can be carried out to a greater degree of accuracy by using meters specifically designed for the purpose, it is felt, nevertheless, that it would be of interest to include a description of the manner in which these functions may be obtained with the oscillograph.

To use the oscillograph as a voltmeter, it is necessary to point out that D. C. measurements cannot be made through the oscillograph amplifiers. Direct connection to the deflector plates must be made. The image observed on the screen will be just one spot, and the location of the spot on the screen will depend on both the polarity and the magnitude of voltage applied. Inasmuch as the voltage required to move the spot 1 inch in any direction is 75 volts (for the 3 inch tube) *without amplifiers,* it is obviously a poor instrument to use when checking 10 volts, for instance.

Further, the screen would have to be calibrated, initially, in terms of volts per inch and, finally, its range would be limited to less than 300 volts.

As an A. C. voltmeter, the aspect of the situation changes in several ways. First of all, the oscillograph amplifiers can be used, and in fact in almost every case, they are used. Secondly, you are viewing a dot no longer, but a straight line, the length of which is easily measured. Third, the straight-line trace represents the highest and lowest voltage amplitudes; in other words, you are viewing the peak voltage, and not the R. M. S. voltage as measured on most A. C. voltmeters.

For example, assume that the amplifiers are switched off, and that no sweep voltage is applied. With an A. C. voltage of 53 volts R. M. S. (as measured on an A. C. voltmeter) applied to the vertical deflector, a straight-line trace of 1 inch, corresponding to 75 volts peak, will be obtained.

Similarly, 106 volts R. M. S. will produce a 2-inch line, corresponding to 150 peak volts. The limit of a 3-inch tube is reached with an input of 159 volts R. M. S. which produces a straight line, extending fully across the screen and representing 225 peak volts.

Of course, switching in the sweep voltage would enable the operator to observe the *wave shape,* in addition to measuring the vertical input voltage amplitude.

As an A. C. voltmeter, with the vertical amplifier switched on, a 3-inch deflection is obtained with approximately 4½ volts R. M. S., as compared with the 159 volts required when not using the amplifier.

In order to use the Oscillograph as an ammeter (whether A. C. or D. C.) it is necessary to use electromagnetic deflection. That is, the current to be measured is passed through a pair of coils placed diametrically opposite each other, one on each side of the glass tube. The deflection obtained should first be produced with a known current; after which other values can be computed. This is another application which is not used very much in practice.

As an ohmmeter, the oscillograph is applicable by measuring the voltage drop across the resistor or other apparatus in the circuit. This method is obviously unsuited for measuring low values of resistance, as outlined above; but, when using the instrument as a null indicator in conjunction with a Wheatstone bridge, a high order of accuracy can be obtained.

It is quite obvious, too, that the instrument can be used as a zero-center galvanometer, with the added advantage that there are no delicate moving coils to burn out.

The manner in which the oscillograph is connected to different pieces of apparatus, for the purpose of measurement or observation, is graphically portrayed in the various figures shown.

Interpreting the viewed image involves a little practice with the oscillograph controls, and also a general idea of what to expect, in the way of an image, from the particular test being conducted.

◆ ◆ ◆

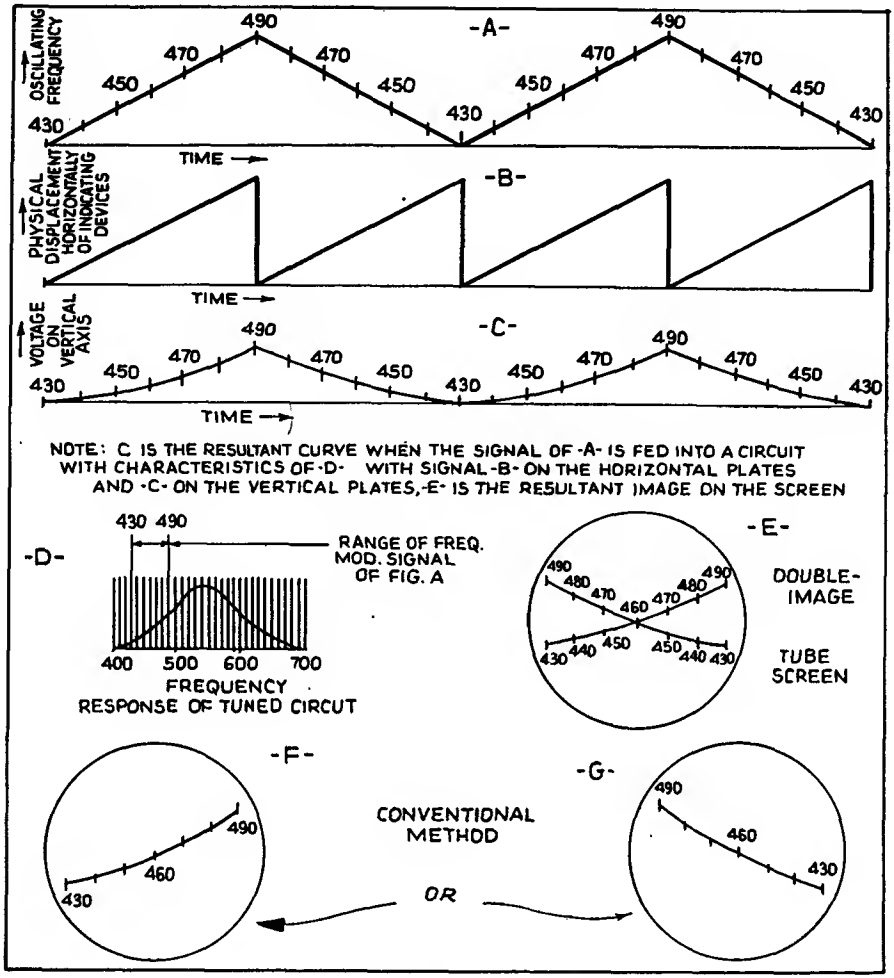


Fig. 41.

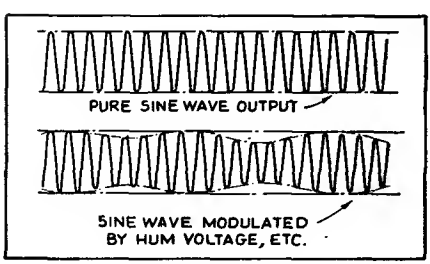


Fig. 42

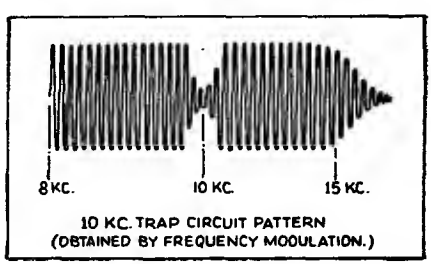


Fig. 43

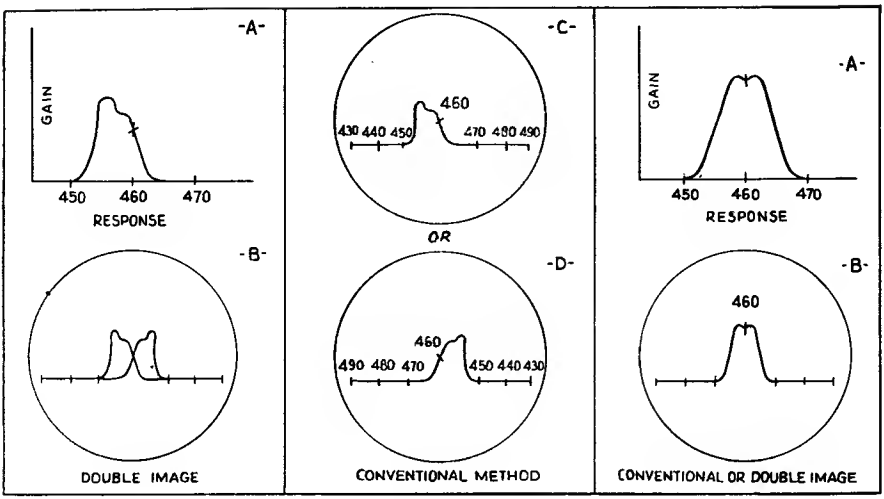


Fig. 44

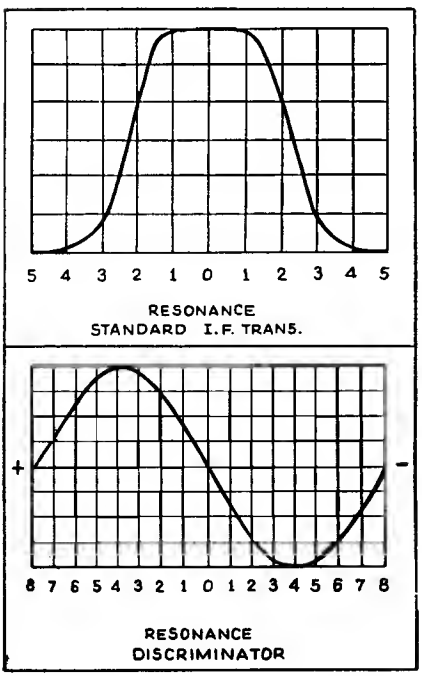


Fig. 45

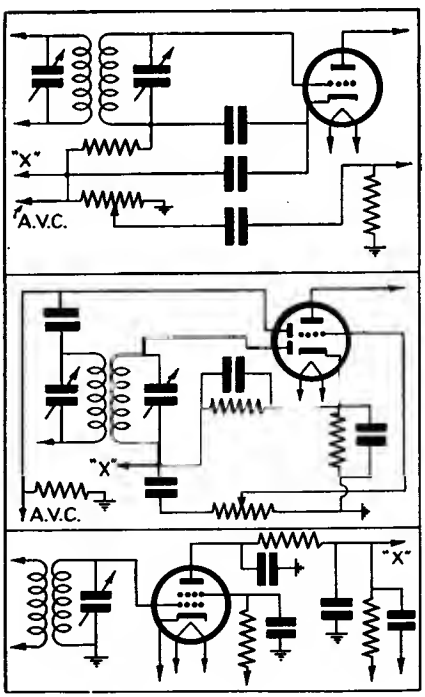


Fig. 46

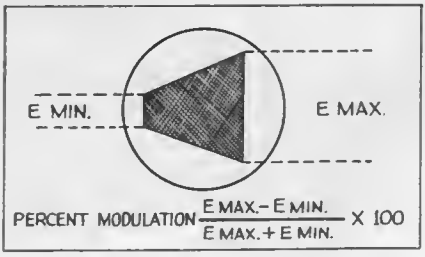


Fig. 47. Left, Trapezoid Pattern

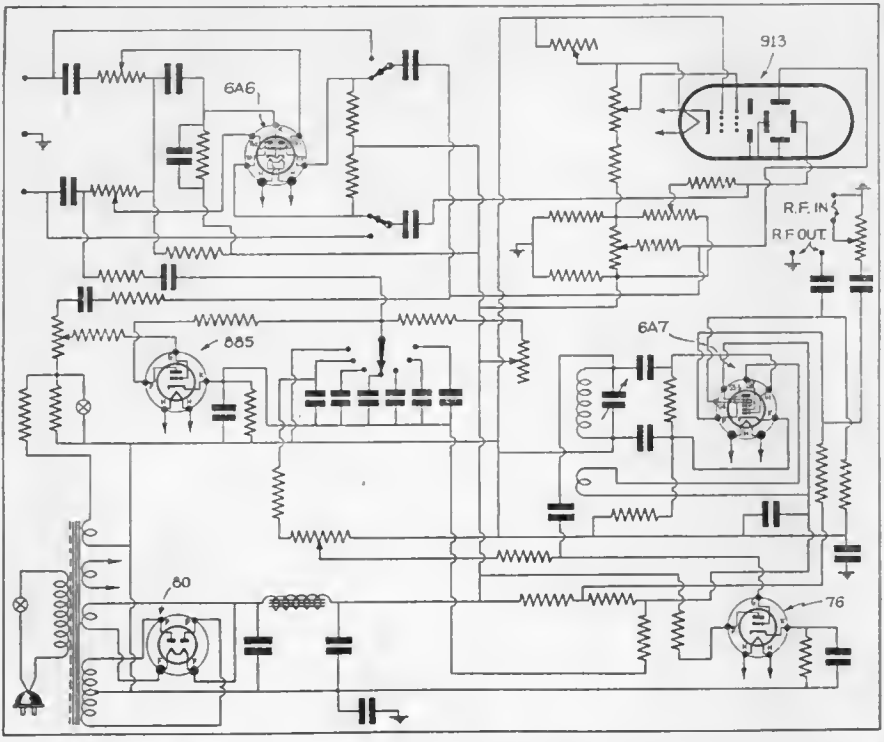


Fig. 48. Above. Triumph Oscillograph Wobbulator and Schematic.

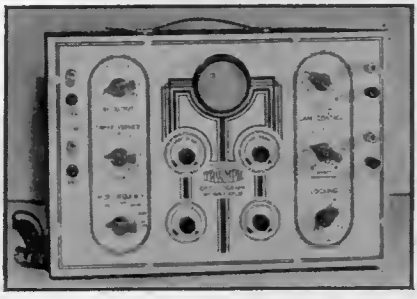


Fig. 49. Above.

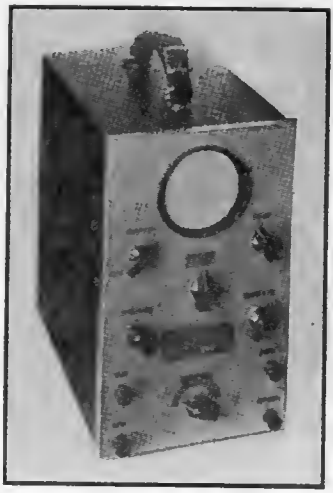


Fig. 50
Dumont 3" Oscillograph
Model 154

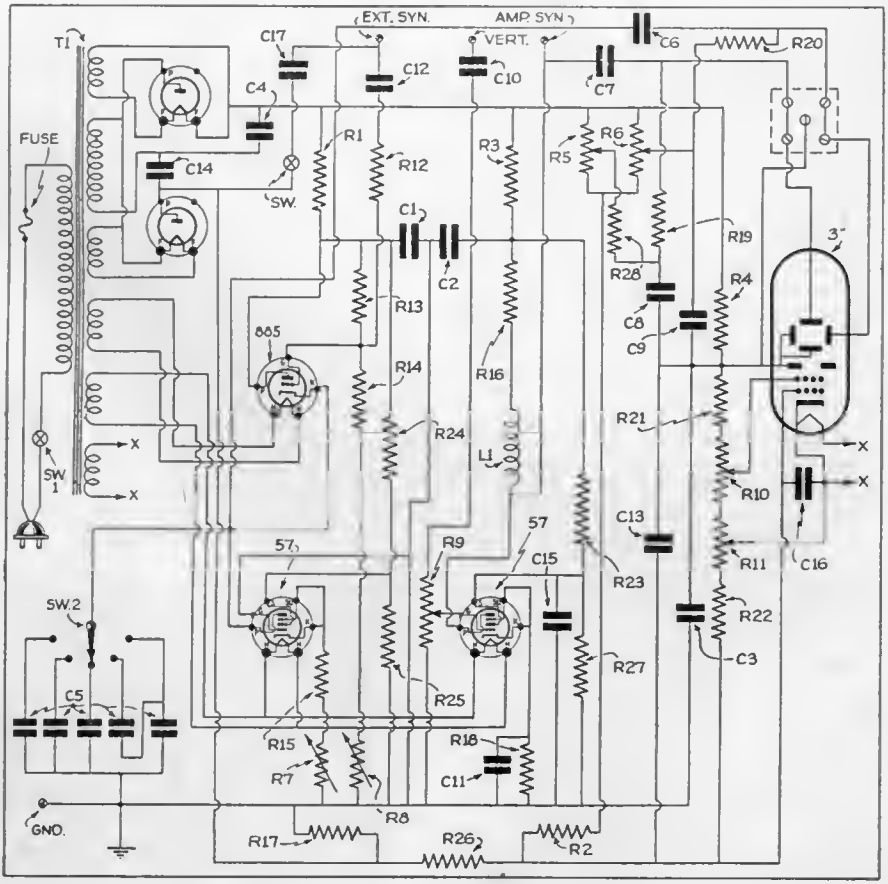


Fig. 50. Schematic of Model 154 Dumont 3" Oscillograph.

Fig. 51.
Dumont 5"
Oscillograph
Model 168

Fig. 51A. Model 168
with cover
removed.

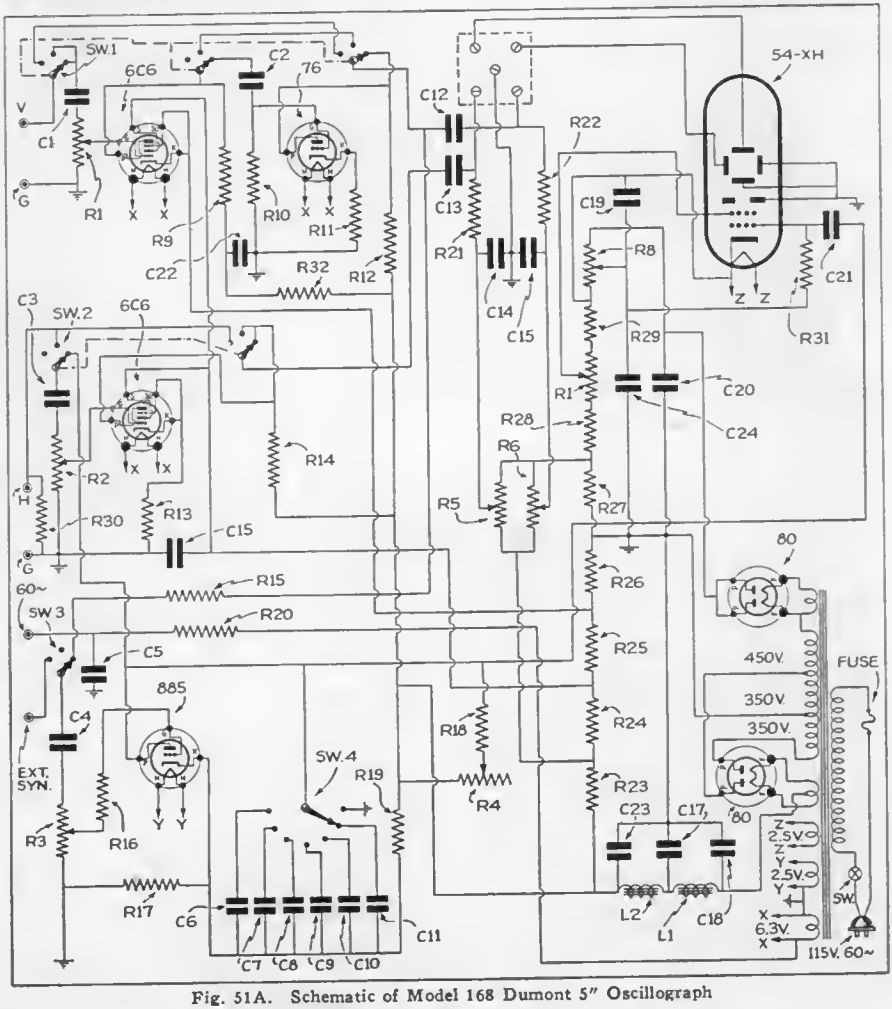


Fig. 51A. Schematic of Model 168 Dumont 5" Oscillograph

CHAPTER 6

Practical Applications of Cathode-Ray Oscillographs

The Oscillograph finds many applications in routine servicing of receivers; one of the most useful being that of visual resonance alignment, of the intermediate-frequency channel in superheterodyne receivers. Another very useful application is that of observing the audio input and output, for distortion and overall performance.

Tracking down noise, distortion and fading are some of its other applications. Some special uses will be given in a later chapter.

The Oscillograph is of great help in checking the modulation of transmitters. The most commonly used method is that which utilizes the trapezoid pattern, obtained by means of the A. F. and R. F. applied to the horizontal and vertical deflectors, respectively. The appearance of the trapezoid, and the formula for determining ing the percentage of modulation, are given in Fig. 47.

Sound systems can be tested for overall gain, overall fidelity, percentage of distortion, degree of phase shift, degree of phase distortion, harmonic distortion, overload, percentage of efficiency, watts output measurement, frequency range, frequency, response and frequency discrimination.

There is no other single instrument that will check all these characteristics with the speed and accuracy of the Oscillograph. It is quite true that a good audio Oscillator must be used as the source of input voltage (to the sound system); but then, the same applies to any other method of measurement.

The Oscillograph has long been used in laboratories to check the performance and characteristics of new design models.

Other practical uses, to which the Oscillograph is put every day, are the quantity production testing of component parts, such as R. F. and I. F. transformers, fixed condensers, A. F. transformers, filter chokes and other parts.

The final check of the completed unit, whether it is an A. F. amplifier or a complete receiver, is also usually done with the aid of an Oscillograph.

For those builders who require a 3-inch Oscillograph which has all the features and appearance of a high-grade commercial unit, we are reprinting the construction details and parts list. The total cost of this instrument was slightly over $40.00.

The instructions are given in three parts, as follows:

Part I for the power supply.
Part II for the sweep circuits.
Part III for the finishing touches.

HOW TO MAKE A 3" OSCILLOGRAPH

The Cathode-Ray Oscilloscope is rapidly becoming indispensible in the servicing of modern radio receivers. It has finally emerged from the laboratory, and is enjoying a steadily-increasing demand among the radio fraternity.

There are at present on the market several commercial portable Oscilloscopes which, because of the fact that they are built around the 3-in. type 906 R. C. A. tube, show a marked similarity of circuit structure. In other words, the circuit is almost standardized, with slight variations.

After careful consideration of all the factors involved, the author decided to build a unit which would contain all the desirable features of the present-day commercial Oscilloscopes and still effect a worthwhile saving in cost.

For those who have kept pace with the development of Oscilloscope equipment and technique, we will list some of the desirable features of this home-built instrument.

1. Portability.
2. Light weight.
3. Ruggedness.
4. Ease of operation.
5. Wide-range sweep oscillator.
6. Wide-range horizontal and vertical amplifiers.
7. Rugged power supply.
8. All controls grouped on panel for greatest efficiency.
9. Impressive appearance.
10. Highest-quality parts.

For the benefit of those who have no knowledge of cathode-ray equipment, we will attempt to give a brief description of its various uses. It enables us to study the wave-shapes of alternating voltages of any frequency; permits measurement of modulation; study resonance curves; study of phase displacements, and dozens of other measurements which we will go into in greater detail later on.

THE 3-INCH CATHODE-RAY TUBE

The tube around which this oscilloscope has been designed contains seven elements, which have terminals on the large 7-prong base. The glass envelope is shaped somewhat like an elongated cone, the "business end" being 3" in dia. and almost flat. This is known as the viewing screen. The white coating on the inside of this viewing screen is a chemical called "willemite," which becomes luminous when electrons strike it.

The seven elements are as follows (refer to Fig. 54): (1) filament; (2) cathode; (3) control-grid; (4) focusing plate; (5) accelerator plate; (6) vertical deflector; (7) horizontal deflector. A back view of the tube base shows where each element terminates. Numbers 1 and 2 connect to the filament which requires 2½ V. at 1.75 A. The cathode is internally connected to the filament prong No. 1.

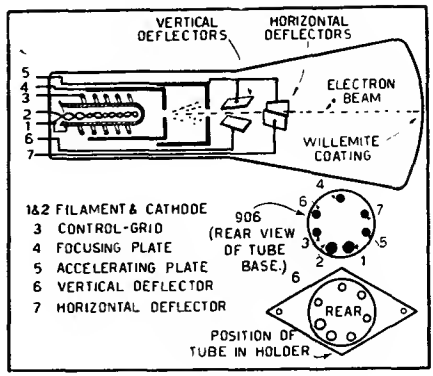


Fig. 54.

Number 3 is the control-grid, which should never be positive. A variable bias voltage is applied to this grid, which can make it negative between 0 and 100V. This element will completely stop electron flow at about 60V. negative bias; it controls the brilliancy or intensity of the electronic beam. The setting of the "Intensity control" determines the dimness or brightness of the image on the screen.

Element No. 4, the focusing plate which attracts electrons from the cathode, is built like a telescope eyepiece; it is a small cylinder with a peep-hole in one end. As the voltage on the focusing plate is variable

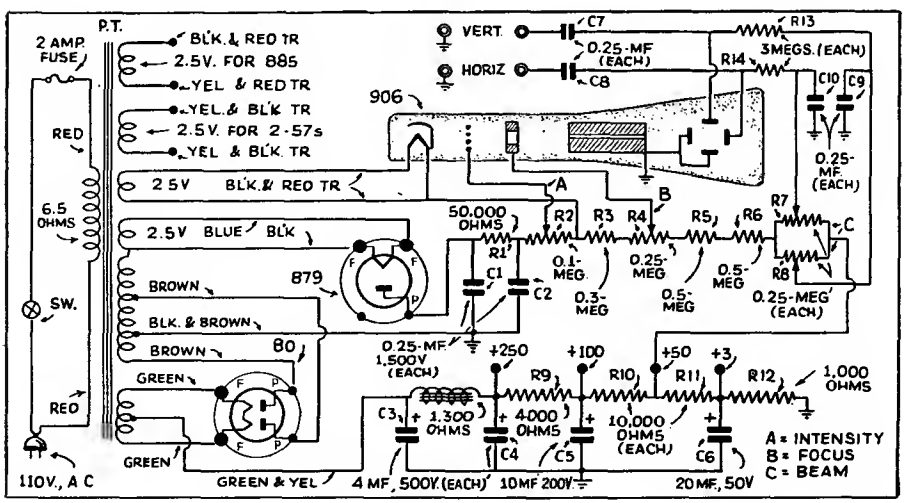


Fig. 53.

(between 200 and 400 V.), it is possible to vary the speed of the electron beam. Reference to the sketch will show that a cloud of electrons is attracted to the focusing plate, and some of them escape through the peep-hole into the next chamber. Increasing the voltage applied to this plate will cause the electron cloud to speed up, and a much larger proportion of electrons will pass through the peep-hole.

Element No. 5 is the accelerating plate, which has a fixed voltage of 1,000 V. applied to it. It, too, is built like a telescope eyepiece. It is larger than the focusing cylinder, but has a smaller peep-hole through which the electron stream is given tremendous acceleration on its way to the viewing screen.

(which is always negative) to be attracted or repelled—depending upon the polarity of the voltage under test—imparting an up or down motion to the spot on the viewing screen.

RELATION OF THE COMPONENTS

We are aware of the fact that a certain number of builders will want to deviate, through choice or necessity, from the parts layout, of electrical units required. This is perfectly permissible, providing the builder has an advanced knowledge of high-voltage power packs, and can compute the resistance values required in voltage distribution for the various branches. For instance, the builder may have on hand a high-vol-

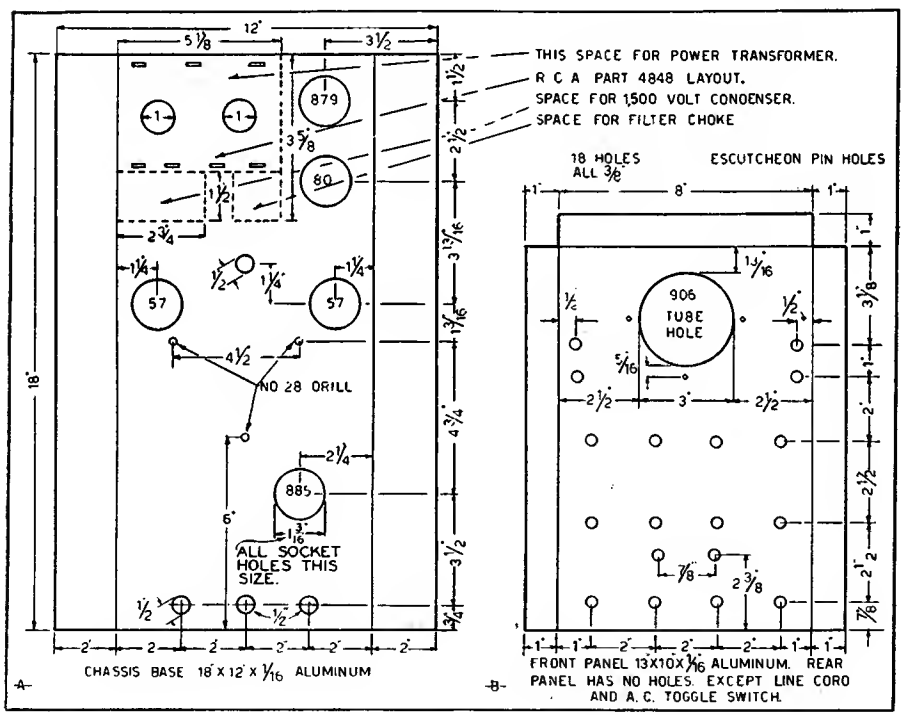

THIS SPACE FOR POWER TRANSFORMER.
R C A PART 4848 LAYOUT.
SPACE FOR 1500 VOLT CONDENSER.
SPACE FOR FILTER CHOKE
18 HOLES ALL 3/8
ESCUTCHEON PIN HOLES
906 TUBE HOLE
NO 28 DRILL
ALL SOCKET HOLES THIS SIZE.
CHASSIS BASE 18 X 12 X 1/16 ALUMINUM
FRONT PANEL 13X10X1/16 ALUMINUM. REAR PANEL HAS NO HOLES EXCEPT LINE CORD AND A.C. TOGGLE SWITCH.

Fig. 55.

Elements Nos. 6 and 7 are two pairs of deflectors, placed at right angles to each other. One deflector of each pair is internally connected to the accelerating plate (which is grounded for safety reasons). The free deflectors terminate at prongs 6 and 7. A voltage applied to the vertical deflector will cause the electron beam

tage transformer requiring a type 81 rectifier.

In this case the transformer might be so large in size, as to require a drastic change in chassis length or width. Therefore, we recommend, to those who are not going to duplicate our instrument, that all the parts, including all tubes, be purchased first.

Then the builder may make his own layout and plan the chassis accordingly.

The complete Oscilloscope contains the type 906 cathode-ray tube; a dual power supply using two tubes; the high-voltage rectifier, type 879; and the low-voltage rectifier, type 80. Only these three tubes will be used at the start. (Later on we will add a saw-tooth oscillator circuit, which contains an 885 gas-triode and associated parts. Still, later, we will add two type 57 tubes, which will serve as wide-range amplifiers for the vertical and horizontal deflectors.)

We are building the unit in easy stages, primarily to help the builder get acquainted with the operation of the unit in its simplest form. After he has mastered the technique of focusing and centering the beam and making simple measurements, he is ready to add the sweep system, which enables him to study wave-shapes and perform advanced measurements.

Lastly, we will add the two amplifiers which increase the size of the image. In the meantime, the financial outlay has been spread over three periods.

A list of the parts needed to construct the unit in its first stage is given.

Figure 53 is the schematic of the first of these units. (Note that two filament windings on the power transformer show no connection. They will be used later. Also note three open taps on the low-voltage divider circuit; they, too, will be used later.) Figure 55A is the chassis base, on which all sockets are marked off; these should be drilled or punched out in advance, even though three of them will not be used at present. The other holes are for the tube mount and other parts which may be slightly shifted around. If sheet aluminum is used, it may be shaped in a tinsmith's brake. No parts should be fastened permanently to the chassis until all holes have been drilled.

Figure 55B shows the front-panel layout. The 3" hole can be cut out by drilling a series of holes inside a circle; after which the jagged edges can be smoothed down with a half-round file. The escutcheon, which is 4" outside dia. and 2⅞" inside dia., requires a 3" hole.

There are twelve holes which are for the various controls, but only the bottom row of four holes will be used at present. The front panel may be riveted or bolted to the chassis after all holes have been drilled.

Figure 57A is the layout of the tube mount. It is the vertical panel upon which an adjustable bakelite plate is mounted. The Isolantite socket, which holds the 906, is fastened to this bakelite plate (which is shown in Fig. 57B.)

Details of the angle bracket which supports the tube mount, are also shown in Fig. 57B. The two brass spacers, ⅝" long, are used between the tube-mounted panel and bakelite plate. Two more are used between the socket and guide plate; thus giving a very high insulation factor to the 906 socket.

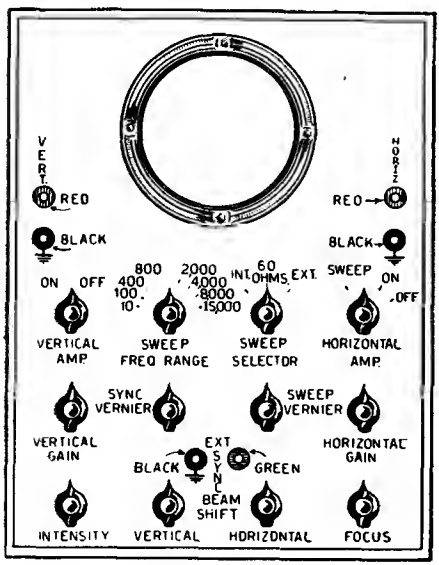


Fig. 56.

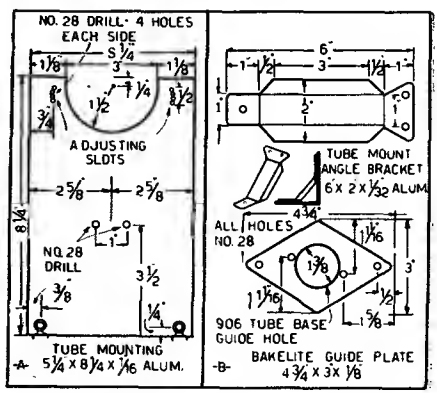

NO. 28 DRILL- 4 HOLES EACH SIDE
ADJUSTING SLOTS
NO. 28 DRILL
TUBE MOUNTING
-A- 5¼ X 8¼ X 1/16 ALUM.
TUBE MOUNT ANGLE BRACKET
6 X 2 X 1/32 ALUM.
ALL HOLES NO. 28
906 TUBE BASE GUIDE HOLE
BAKELITE GUIDE PLATE
-B- 4¾ X 3 X ⅛

Fig. 57.

The small parts are mounted underneath the chassis. The resistors and bypass condensers may be assembled on a small fibre or bakelite panel. The "Focus" potentiometer is mounted on the front panel in the extreme right hole of the bottom row of four holes. Refer to Fig. 58. The "Intensity" control is placed in the extreme left hole. The two remaining holes in the center are occupied by the 'Beam Shift' potentiometers. (The remaining eight holes will be used later).

Three sets of tip-jacks are mounted next. Note that the black tip-jacks are grounded to the metal front panel; the red and green tip-jacks must be insulated from the panel. The escutcheon is mounted with small screws or pins. Line-up the cathode ray tube with the escutcheon *before* permanently fastening the tube mount.

Wiring is the next operation. To simplify matters, the wiring should be done in groups, as follows: high-voltage plates and filament; low-voltage plates and filament; high-voltage condenser and resistor; low-voltage, filter choke.

A 7-wire cable about 2 ft. long (or seven separate wires) may be passed through the ½" rubber grommet directly beneath it, and the wires are then connected to the four panel controls and high-voltage divider circuit.

The four power transformer filament leads that are not used at present should be individually taped, and tied down out of the way. Adding the line switch and cord completes the job. The line fuse is optional.

NOTE: It is a safe bet that every Service Man has, at some time or other, been "kicked" by four or five hundred volts, and laughed it off. *BUT, BE WARNED*: 1200 volts is a potential that is not to be trifled with!

Now we prepare the unit for its initial test. Plug into the red and black tip-jacks (on both side of the escutcheon) two pairs of test leads with clips. If you have a 45-V. "B" battery on hand, it will serve as the deflecting-voltage source in our first experiment.

Plug the unit into the line and wait about a minute for the tubes to warm up, and then look at the viewing screen. If the spot is invisible or very dim, turn up the "Intensity" control, gradually, until the spot is about 1/64" across and easily seen, but not too bright or glaring. If the spot has a halo around it, gradually turn the "Focus" control, until the halo disappears and the spot is sharp and clear. Next the "Beam Shift" potentiometers may have to be adjusted to center the spot; and once done, this adjustment may not have to be disturbed for a long while.

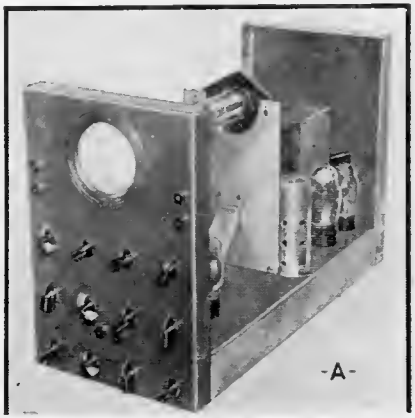


Fig. 58.

Now we will test the deflector plates both separately and together, with the "B" battery. Connect the red vertical to plus and the black to minus. The spot should move upward about ½". Now, reverse the leads, and the spot should move downward ½" (from center). Remove the vertical deflector connections from the battery and connect the horizontal; as before, plus to red and minus to black. The spot should move to the right along its center for about ½". Reverse the connection and the spot should move to the left.

Many other simple and interesting measurements may be performed. It is suggested that the builder practice with the unit until he is familiar with the operation of it. The construction and operation of the wide-range sweep oscillator will be described in Part II.

LIST OF PARTS

Power Supply and Basic Components.
One 3". Cathode-Ray Oscilloscope tube.
1 R. C. A. 978 rectifier tube.
1 80 rectifier tube.
One chassis, front and rear panel, tube panel, tube mount and bracket, sheet aluminum (see detail illustrations for dimensions).

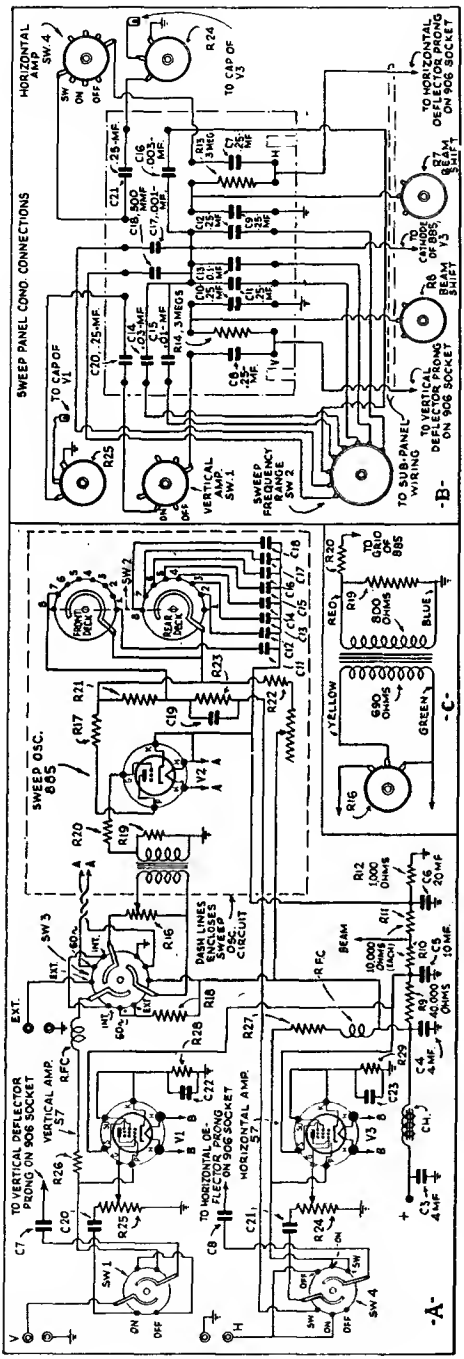


Fig. 59 A—B—C

One power transformer, No. 4848, P. T.
Two condensers, 1500 V., 0.25 mf., C1, C2.
One filter choke, 1300 ohms, No. 4846.
Two electrolytic condensers, 4 mf., 500 V., C3, C4.
One electrolytic condenser, 10 mf., 200V., C5.
One Electro. cond., 20mf., 50V., C6.
Four condensers, 0.25mf., 400 V., C7, C8, C9, C10.
One resistor, 50,000 ohms, 1 W., R1.
One potentiometer, 0.1 meg., R2.
Three potentiometers, 0.25 meg., R4, R7, R8.
One large 7-prong isolantite socket.
Two 4-prong sockets.
Two resistors, 3 megs., ½W., R13, R14.
Two resistors, 0.5 meg., 1 W., R5, R6.
One resistor, 0.3 meg., 1 W., R3.
Two resistors, 10,000 ohms, 1 W., R10, R11.
One resistor, 1,000 ohms, 1 W., R12.
One wire-wound resistor, 40,000 ohms, 5 W., R9.
Four pointer knobs.
One 4 in. escutcheon (for the Cathode-Ray tube).
Six tip-jacks, 3 black, 2 red, 1 green.
One A. C. toggle switch.
One fuse mount and 2 A. fuse.
Hookup wire with good insulation.

Part II

SWEEP CIRCUITS

We have described the construction and elementary operation of a simple cathode-ray oscilloscope. We are now ready to add a wide-range sweep oscillator to the unit. The schematic is given in Fig. 59.

Its primary use in the cathode-ray oscilloscope is to move the luminous spot across the screen at a definite rate; which permits the vertical voltage under test to be spread across the screen.

The sweep-oscillator circuit is built around the R. C. A. 885 grid-controlled gas triode. This tube is ideally suited for the generation of the saw-tooth wave which is required.

The range of frequencies generated extends from 10 cycles per second, up to approximately 18,000 cycles per second. With 5 cycles of signal voltage on the screen of the 906, it is possible to study waveforms directly up to about 90,000 cycles.

The constants of the circuit are such, that the only part of the sweep output voltage used is the linear portion of each charging cycle. The circuit is stabilized against inherent drift by the fixed bias and grid-suppressor method.

The sweep voltage mentioned above, however, is now of insufficient amplitude to swing the electron beam across the screen of the 906. Therefore, an amplifier is used to increase the sweep voltage amplitude. This amplifier is always on; but its input and output circuits may be switched to "ON," "OFF" or "SWEEP."

The various controls and switches associated with the sweep oscillator are used for the purpose of selecting the various frequencies, controlling the output, synchronizing the input voltage and "locking" the image on the screen.

A complete list of the parts required is given later. We will refer to the list from time to time as we proceed with the discussion.

A Cathode-Ray Oscillograph without any sweep circuit has a definitely limited field of application, as far as the radio servicing branch of the industry is concerned. We mean to emphasize the fact that the addition of the sweep circuit is of vital importance to the utility of the instrument as a whole. It follows therefore that, the more knowledge relating to sweep circuits the reader has, the better equipped he is to cope with problems arising from operation and interpretation of signal images.

In the meanwhile, for the prospective builder who may not care to delve into the design considerations of sweep oscillators, we will give a mechanical analogy which, we hope, will at least give him a rough idea of the function of sweep circuits in general.

We will assume that a gallon capaciy pail is to be filled to the top with water. This requires, we will say, 15 seconds. When the pail is full, we turn it upside down, and empty it completely in one second. Electrically, this would represent

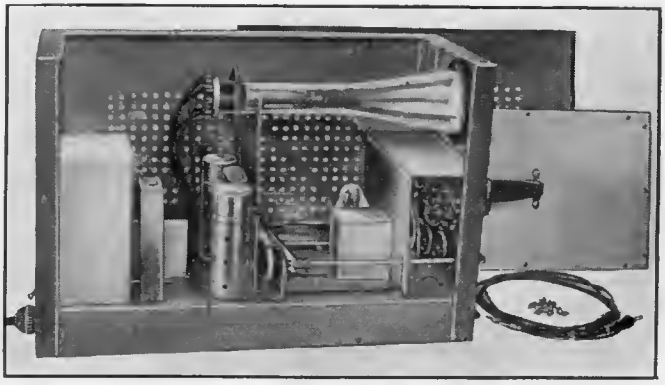


Fig. 60 A

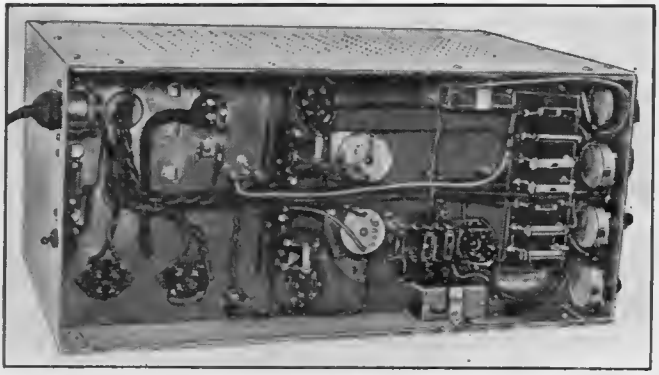


Fig. 60 B

one cycle of the saw-tooth wave. The gallon pail represents a condenser which is being charged with current. When the condenser is fully charged (assume it has taken 15 seconds) it discharges in one second.

However, this is not all that happens. To continue with the mechanical analogy, assume that the gallon pail is exactly 12" deep; when it is empty, the water pouring in has to travel 12" to the bottom. As the pail fills, the distance becomes less and less until it reaches the top; whereupon it is emptied in one second as before. Now, we have established both the time and the distance, representing frequency and amplitude. If we cut the pail to a depth of 6", it would require only 7½ seconds to fill it up, and the water would only have to travel 6" from bottom to top. Therefore, we would be able to fill the pail eight times in one minute, instead of four as in the previous case. In other words, we have doubled the frequency and cut the amplitude in half.

The water slowly filling the pail to the top represents the voltage, which is slowly moving the electron beam across the screen. Assume, as before, that 15 seconds is required to move the luminous spot across the screen, a distance of 2". At the end of the charging current cycle, the electron beam is instantly returned to its former position, and a new cycle starts. Of course, in practice, the spot always moves across the screen faster than 10 times in one second; thereby producing a solid horizontal line extending across the screen. That is, with no voltage applied to the vertical deflector; but, when any voltage is applied to the vertical input jacks, the electron beam will move up or down or both, as well as sideways—thus producing an image which has all the variations of the voltage itself.

Now, before we proceed with the constructional details pertaining to the addition of the sweep circuit, we want to make it clear that the complete oscilloscope has a pair of type 57 amplifiers which are used to increase the input sensitivity of the 906 to a point where 2 volts input will cause a 1" deflection on the screen. Without these amplifiers, 75 volts would be required to obtain the same 1" deflection.

The vertical amplifier may be omitted until later, but the horizontal amplifier circuit is so interwoven with the sweep-oscillator circuit that it was deemed best to include it in this part. The additional parts required for the vertical amplifier are few and have been included in the parts list.

CONSTRUCTION

First, a 5-prong socket is mounted on the chassis, in the hole which was previously drilled for it. If no hole was provided in the initial construction, refer to the chassis layout in Part I and follow specifications.

To the left of the 5-prong socket, mount the sweep input transformer. If the recommended transformer is not used, obtain a 1:1 ratio, low-impedance audio transformer, having a D. C. resistance of about 1,000 ohms on both the primary and secondary.

Mount on the front panel, the following parts: facing the front panel, the top row of four ⅜" holes will be occupied by 4 switches. The extreme left hole is for the vertical-amplifier switch, which is 1-gang, 2-pole, 2-tap.

In the next hole is mounted the sweep-frequency range switch which is 2-gang, 8-tap. Then comes the sweep-selector switch which is 1-gang, 3-pole, 3-tap. In the extreme right hole is mounted the horizontal amplifier switch, which is 1-gang, 2-pole, 3-tap.

The center row of four ⅜" holes is filled as follows: Extreme left, vertical-gain potentiometer. Next, synchronizing-vernier potentiometer. Next, frequency-vernier rheostat, and, in the extreme right hole, horizontal amplifier potentiometer. Neither gain control is mounted directly on the front panel, but ¼" shaft bushings are placed in the extreme left and right holes. Quarter-inch aluminum shafts extend from the front panel to the controls, which are mounted on small angles placed very close to each amplifier tube shield.

A bakelite panel should now be prepared for the mounting of 14 by-pass condensers. Eight of these condensers are 0.25-mf.; the rest range in size from 0.1-mf. down to 500-mmf. It is suggested that this panel be mounted upright, midway between the front panel and the sweep input transformer. If this plan is followed, the leads from

the sweep-frequency range switch to the eight different condensers will be short, and the wiring capacity will be very low. Two slots are cut into the panel for the passage of the two aluminum shafts.

Figure 59B shows the recommended layout for the various condensers.

Figure 61A gives the dimensions for the sweep panel top shield. This shield prevents stray electrostatic fields, which may be produced by the condensers beneath, from affecting the electron beam, in the 906 directly above. It is grounded to the front panel by fastening it under the two black tip-jack lock-nuts. It serves also as a brace for the bakelite panel to which it is fastened and finally, it enhances the appearance of the "innards."

Figure 59A shows a rear view of the four switches together with the proper terminal designated. These special switches come with rather long shafts, which must be cut ½" from the start of the threaded shanks. Lock washers should be used on all shanks, to prevent future loosening.

Panel wiring above the base, which must pass through the chassis, should be routed through the proper grommet in the row of three, directly behind the front panel.

By following Fig. 59 very carefully, the switch wiring may be done quickly and neatly, in fact, the switch wiring which will remain above the base may be left a few inches longer to make it easier when the sweep panel is hooked up. The sub-base wiring is not difficult. Small bakelite terminal strips will help a great deal to produce a very neat and rugged wiring and resistor assembly.

The four 0.25-mf. condensers C7, C8, C9, C10, which were used in the first stage unit may be removed and placed on the sweep panel, if desired.

The wiring and parts required for both amplifiers are almost identical; that is, each amplifier has a plate resistor, R. F. choke, bias resistor, and condenser of equal values. The horizontal amplifier is wired first. If the additional parts needed for the vertical amplifier are at hand, there would be no point in waiting to add them later on.

This completes the wiring and, as before, the circuits should be tested carefully for continuity, shorts and possibly poor soldered joints.

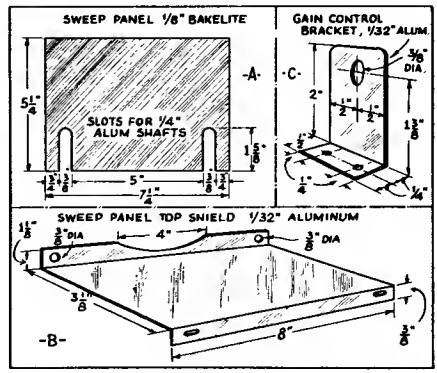


Fig. 61.

LIST OF PARTS FOR SWEEP CIRCUIT

One sweep selector switch, 1-gang 3 pole 3 tap, Sw. 3.

One sweep frequency range switch, 2 gang 8-point, Sw. 2.

One frequency vernier control, 2 megs., R15.

One synchronizing vernier control, 1,000 ohms, R16.

One sweep input transformer, part No. 4847.

One wafer socket, 5 prongs.

One type 885 tube.

Two tubular by-pass condensers, 0.25 mf., 400 V., C11, C12.

One tubular by-pass condenser, 0.01 mf., 400 V., C13.

One tubular by-pass condenser, 0.03 mf., 400 V., C14.

One tubular by-pass condenser, 0.01 mf., 400 V., C15.

One mica postage-stamp type condenser, 0.003 mf., 400 V., C16.

One mica postage-stamp type condenser, 0.001 mf., 400 V., C17.

One mica postage-stamp type condenser, 500 mmf., 400 V., C18.

One mica postage-stamp type condenser, 50 mmf., 400 V., C19.

One carbon resistor, 200 ohms, 1 W., R17.

One carbon resistor, 1,000 ohms, ½ W., R18.

One carbon resistor, 5,000 ohms, ½ W., R19.

One carbon resistor, 10,000 ohms, ½ W., R20.
One carbon resistor, 0.3 meg., ½ W., R21.
One carbon resistor, 0.4 meg., ½ W., R 22.
One carbon resistor, 0.75 meg., ½ W., R 23.
Six lug terminal strips, 6 lugs on each.

VERTICAL AND HORIZONTAL AMPLIFIER

Two wafer sockets, 6 prong.
Two tube shields.
Two type 57 tubes.
Two grid caps.
Two gain controls, 0.5 meg., R24, R25.
Two ¼" shaft couplings.
Two ¼" aluminum shafts, 8½" long; Two ¼" bushings with ⅜" shanks;
One horiz. amp. switch, 1-gang 2-pole 3-tap Sw. 4;
One vert. amp. switch, 1-gang, 2-pole 2-tap Sw. 1;
Two tubular cond. 0.25-mf., 400 V., C 20, C21;
Two tubular cond. 0.004-mf., 400 V., C 22, C23.
Two shielded R. F. chokes, 80 Millihenries;
Two carbon resistors, 0.1-meg., 1 W., R 26, R27;
Two carbon resistors, 850 ohms, ½-W., R28, R29;
Eight pointer knobs.

Part III

FINISHING TOUCHES

We are now going to describe the function of each control on the completed instrument.

CASING DETAILS

The chassis is walled-in on the left and right sides, by sheet aluminum (See Fig. 62, upper-left). It is recommended that the bends be made on a tinsmith's "brake." The sidewalls should have an ample number of holes drilled for ventilation purposes. The sketch shows that a geometric patterns was followed in our instrument. However, the builder may use whatever pattern he desires. Just be sure that at least 100 holes of ¼" dia. are drilled out.

Hexagon-head self-tapping screws, ¼" long, are used throughout for fastening the sides, top and bottom (the size of these screws is equivalent to the 6/32 machine screw). The self-tapping screws require a No. 28 drill hole for clearance and a No. 33 drill hole for the self-tap. The clearance holes (No. 28) are drilled in the sidewalls as shown on the figures; then the side is placed in position on the chassis, and the tap holes may be marked off with an ice-pick or other sharp pointed tool. In this way, the holes in the chassis will match perfectly with the holes in the sidewalls.

When both sidewalls have been screwed into place, the top section (upper right, Fig. 62) is prepared and the same procedure is followed.

The unit, when used in locations which have powerful magnetic fields, will require a galvanized sheet iron shield surrounding the 906, as detailed at lower-left in Fig. 62. In many cases, thought, this shield may not be needed.

Stray images might be seen on the screen when test leads are plugged in and left free.

Last, but not least, the bottom plate is prepared. (See Fig. 62, lower-right.) This plate requires two right-angle bends, and should be lined on the side facing inward, with thick insulating paper. The right-angle bends are sandwiched between the chassis and sidewalls. Three self-tapping screws on each side hold the bottom plate in place. Four rubber feet are mounted, one in each corner on the bottom. A carrying grip may be dispensed with, if the unit is to be used in one permanent spot. Three pairs of test leads should be made or purchased, since all three may be needed on certain tests; at least one of these test leads should be shielded with tinned copper braid and ½" thick insulation for use in R. F. tests.

The last item needed is an engraved front panel card, which shows what each knob controls. This may be made by the builder by referring to the front panel sketch in Part 1.

On the front panel of the completed Oscilloscope, there are 12 knobs and three pairs of tip-jacks; each contributes in some way to the ease of operation, or to conven-

ience, or to the versatility of the instrument in its many applications. To many, this multiplicity of knobs may be a bit confusing at first glance; however, if the purpose of each control is studied and memorized in proper order, you will appreciate them more and more as you gain experience through practice.

THE TOP ROW OF CONTROLS.

Refer to Figs. 56 and 54 (Part 1) for the control layout and ray-tube element arrangement, respectively, and to Fig. 59 in part II for the complete schematic circuit.

Taking one at a time, from left to right, we have first the vertical amplifier ("Vertical amp.") switch. Associated with this switch are the vertical input tip-jacks (Vert., red and black) on the extreme left of the panel. Let us assume, throughout the discussion, that a sine wave of 120 cycles per second in frequency will be used as a "signal voltage."

With the Vertical amp. switch set to "OFF," the signal voltage applied to the Vert. input tip-jacks will travel through the switch arms and through the blocking condenser C7 to the vertical deflector of the 906. In this case, the signal voltage must have an amplitude of 75 peak volts to cause a 1" deflection on the screen.

When the Vertical Amp. switch set to "ON," however, the signal voltage is fed through a blocking condenser, C20 and gain control R24 into the grid of a 57 amplifier, which has a gain of approximately 38. With 2V. input to the control grid of

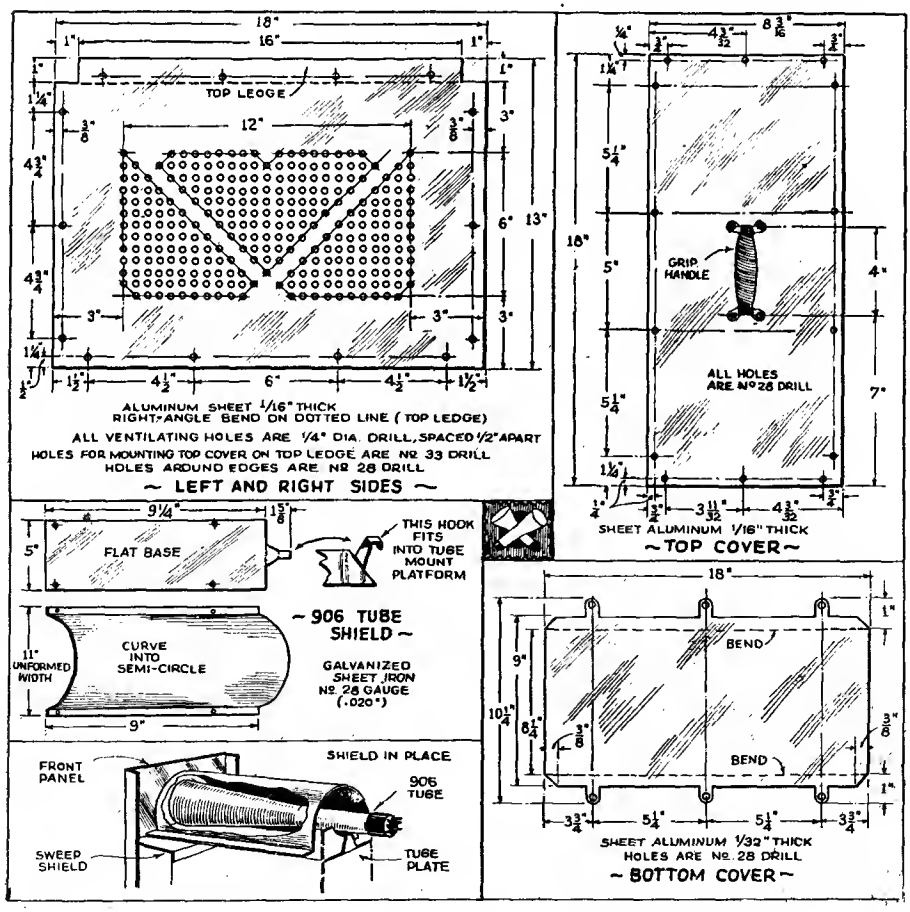

TOP LEDGE
ALUMINUM SHEET 1/16" THICK
RIGHT-ANGLE BEND ON DOTTED LINE (TOP LEDGE)
ALL VENTILATING HOLES ARE 1/4" DIA. DRILL, SPACED 1/2" APART
HOLES FOR MOUNTING TOP COVER ON TOP LEDGE ARE NO. 33 DRILL
HOLES AROUND EDGES ARE NO. 28 DRILL
~ LEFT AND RIGHT SIDES ~
GRIP HANDLE
ALL HOLES ARE NO. 28 DRILL
SHEET ALUMINUM 1/16" THICK
~ TOP COVER ~
FLAT BASE
THIS HOOK FITS INTO TUBE MOUNT PLATFORM
~ 906 TUBE SHIELD ~
CURVE INTO SEMI-CIRCLE
GALVANIZED SHEET IRON NO. 28 GAUGE (.020")
SHIELD IN PLACE
FRONT PANEL
906 TUBE
SWEEP SHIELD
TUBE PLATE
BEND
SHEET ALUMINUM 1/32" THICK
HOLES ARE NO. 28 DRILL
~ BOTTOM COVER ~

Fig. 62.

this tube, an output of 76 V. will result and is applied, as before through C7 to the vertical deflector of the 906, causing a 1" vertical deflection. You can readily see that, without the vertical amplifier, we would be unable to measure very low voltages.

The second knob in the top row controls the sweep frequency range switch ("Sweep Freq. Range") which has eight taps.

The sweep oscillator generates a sawtooth wave, the frequency of which is variable, from 10 cycles per second up to about 18,000 cycles per second. This total range is broken up into 8 smaller ranges by the tap switch.

The frequency limits for each tap are approximately as follows: No. 1, 10 to 40; No. 2, 20 to 60; No. 3, 50 to 200; No. 4, 120 to 450; No. 5, 350 to 1400; No. 6, 850 to 3500; No. 7, 2000 to 7000; No. 8, 5000 to 18,000 cycles.

It is understood, therefore, that when the knob is set at any one of the eight taps, you are "tuned" to a *band* of frequencies; which is why this switch is sometimes referred to as the "rough" frequency control. In order to reproduce one cycle of the sine-wave input at the Vert. input jacks, it is necessary to match the sweep frequency with the signal frequency. This can rarely be done with the "rough" control alone, but can readily be accomplished by proper use of the frequency vernier ("Sweep Vernier"), of which more later.

The third knob in the top row controls the sweep-selector switch ("Sweep Selector"). Each of its three positions is important; therefore we will describe the function of each. Before doing so, we want to state that the term "sweep selector" is used for convenience, and it does not really select the sweep frequency as its name might imply. Strictly speaking, it enables us to select the synchronizing pulse from any one of three separate sources, designated as "internal" or INT.; 60 cycles; and "external" or EXT. (Note that the illustration, Fig. 56, designates this as "60 ohms." We apologize for this slip-up.)

With the knob set to "INT.," and the Vertical Amp. set to "ON," the signal voltage applied to the Vert. tip-jacks will be amplified through the type 57 tube. In the plate circuit of this tube there is flowing an amplified version of the original input voltage. Note carefully that this signal voltage, together with the "B" supply voltage for the tube, flows through the three arms of the switch *only* when the switch is set to "INT." and the Vertical Amp. is set to "ON." Note further that the synchronizing vernier is permanently connected across two arms of the selector switch; the movable arm and one side of the Sync. Vernier are, in turn, connected across the primary of the sweep input transformer.

With the controls set as mentioned, a certain amount of signal voltage will flow through the Sync. Vernier and through the transformer primary; thence through the secondary, to the control-grid of the 885. The amount of signal voltage impressed on the primary can be controlled by the operator through the Sync. Vernier. The final result is that the sweep oscillator starts its cycle in synchronism with the signal voltage.

With the knob set on the "60 cycles" position, the 60-cycle pulse is obtained from one of the filament windings in the unit. The Vertical Amp. may be "ON" or "OFF" and, in either case, the amount of voltage impressed on the control-grid of the 885 is controllable through the Sync. Vernier. The 60-cycle pulse is useful mainly when it is desired to study 60-cycle voltage or any multiple of 60 cycles, up to about the 10th harmonic, or 600 cycles.

The last position is the "External." The EXT. tip-jacks are now brought into play. In the other two switch positions, these tip-jacks are completely out of circuit. Whenever the need arises, the synchronizing pulse from any desired external source is fed into these tip-jacks; but bear in mind that the impedance of the input circuit is very low.

It is necessary, therefore, to add a resistance of about 0.1 meg. in series, to prevent overloading of high-impedance circuits. Again, the Sync. Vernier controls the amount of voltage desired.

The horizontal amplifier switch ("Horizontal Amp.") is placed at the extreme right. This switch also has three positions. In practice, the position most used is the sweep tap, marked "Sweep." In this position, a portion of the sweep oscil-

lator output is fed into the horizontal amplifier grid, amplified, and then to horizontal deflector of the 906. The horizontal line across the screen may be lengthened or shortened by means of the Horizontal Gain control. In this position the Horiz. tip-jacks are out of circuit and therefore it is not possible to introduce any external voltage into the horizontal deflector.

When the switch is set to "ON" tap, the sweep oscillator is disconnected and the horizontal tip-jacks are in circuit. Any external voltage applied to the Horiz. tip-jacks is now amplified and passed on to the horizontal deflector. In this position, it is possible to use an *external* sweep oscillator of different characteristics than the built-in sweep.

The "OFF" position is used mainly for high input voltages. In this position the internal sweep is disconnected and so is the horizontal amplifier.

THE CENTER ROW OF CONTROLS. The positions of each are as follows: extreme left, Vertical Gain control; next, Sync. Vernier; next, Sweep Vernier; and, extreme right, Horizontal Gain control. We already know that the vertical and horizontal gain controls are in use only when their associated amplifiers are "ON" and control the length of the vertical and horizontal deflection trace.

The Sync. Vernier, as we know, controls the amount of voltage applied to the 885 control-grid, and serves to keep the oscillator locked in frequency with this grid pulse. This is not all, however. The position of the knob controls, or at least exerts an influence on the following factors: distortion of the image; speeding up of the image; changing the frequency of the image; and, finally, stopping of the image. Practice is necessary, to avoid over-and under-synchronizing.

The Sweep Vernier control is used to change the sweep frequency in small steps until a suitable number of cycles appear on the screen. As a rule, 3 cycles on the screen are usually sufficient for most waveform tests. However, when frequencies in excess of 50,000 cycles are to be tested, there will appear *no less* than 3 and possibly 4, 5 or 6 cycles on the screen. This is due to the ratio of viewed frequency against sweep frequency.

For example, a vertical voltage has a frequency of 90,000 times per second, while the sweep frequency is flashing horizontally across the screen at 15,000 cycles per second. The result is, that 6 complete cycles will appear on the screen; because the sweep frequency is 6 times *slower* than the viewed frequency.

THE BOTTOM ROW OF CONTROLS

We are now going to add a few important hints to supplement the description given in Part I.

Do not connect *any* test leads to *any* tip-jacks before or during the process of focusing the spot on the screen. This precaution *must* be observed; any stray voltage picked up by the test leads will be amplified and applied to either or both deflector plates, causing the spot to blur. It is also advisable to have both amplifier switches set on their "OFF" positions, while the focusing process is on. When the spot has been properly focused, the amplifiers may be switched on and external voltages may be applied.

However, when the spot is set into rapid motion, it may become very dim. In such cases *only* the Intensity control should be moved; and then only enough to make the trace plainly, but not glaringly visible.

The beam-shift potentiometers are connected to the voltage divider in such manner that the cathode-ray beam is shifted at will, and to any part of the screen, by the operator.

D. C. voltages cannot be measured with this unit *unless* the input blocking condensers C7 and C8 are shorted out and both amplifiers are "OFF." An easier method would be to connect a wire at each socket prong, directly to the vertical and horizontal deflectors.

Now that we have completed the construction of the Oscilloscopes, we are concerned, naturally, with the practical uses to which the instrument may be put. We shall endeavor to show how the instrument should be connected to the various pieces of apparatus under test, so that the builder may avoid misleading results and needless waste of time.

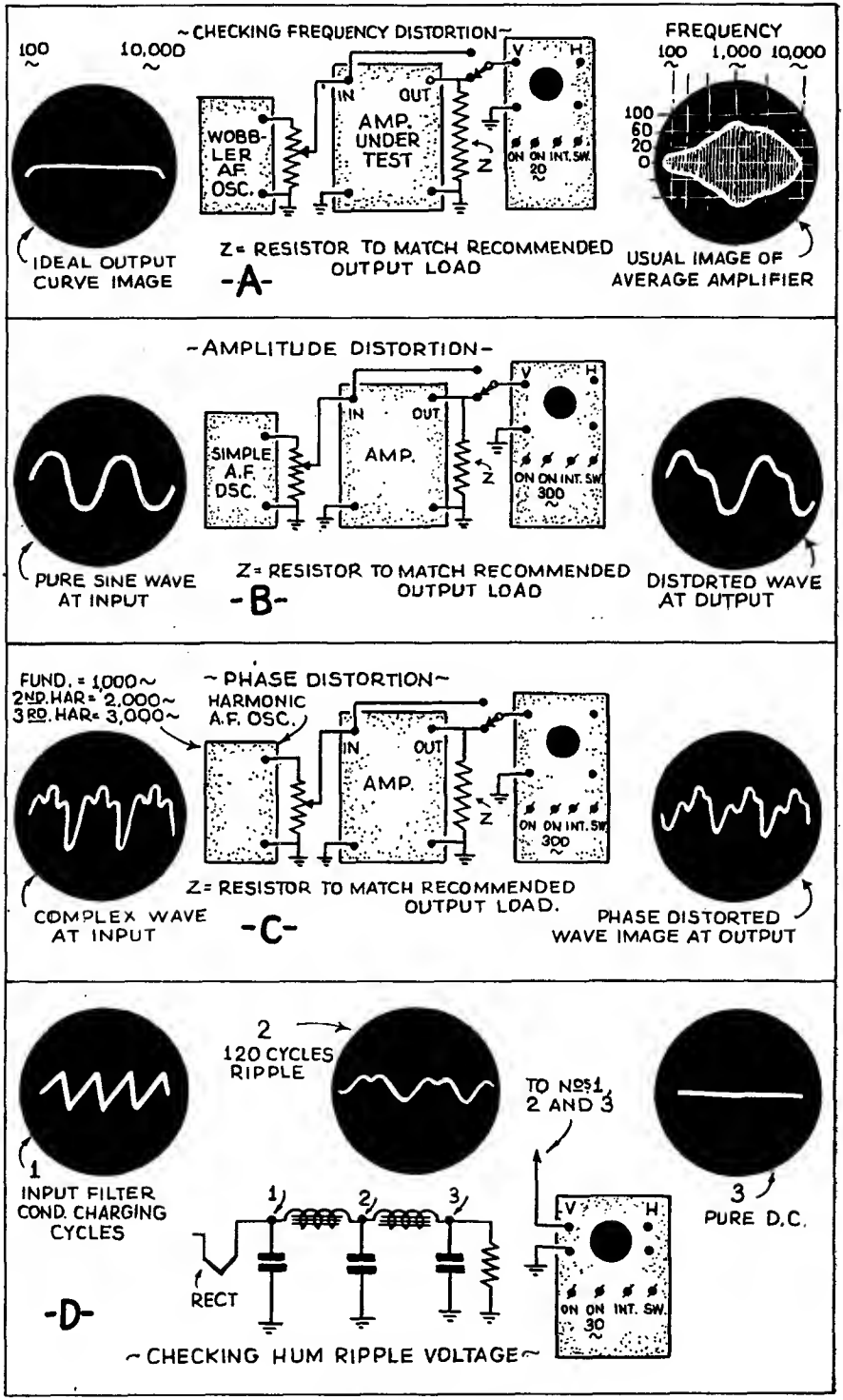

~CHECKING FREQUENCY DISTORTION~
100
10,000
WOBB-LER A.F. OSC.
IN
OUT
AMP. UNDER TEST
Z
V
H
ON ON INT. SW. 20
FREQUENCY
100 1,000 10,000
100
60
20
0
IDEAL OUTPUT CURVE IMAGE
Z = RESISTOR TO MATCH RECOMMENDED OUTPUT LOAD
-A-
USUAL IMAGE OF AVERAGE AMPLIFIER
~AMPLITUDE DISTORTION~
SIMPLE A.F. OSC.
AMP.
ON ON INT. SW. 300
PURE SINE WAVE AT INPUT
Z = RESISTOR TO MATCH RECOMMENDED OUTPUT LOAD
-B-
DISTORTED WAVE AT OUTPUT
FUND. = 1000~
2ND. HAR = 2,000~
3RD. HAR = 3,000~
~PHASE DISTORTION~
HARMONIC A.F. OSC.
AMP.
ON ON INT. SW. 300
COMPLEX WAVE AT INPUT
Z = RESISTOR TO MATCH RECOMMENDED OUTPUT LOAD.
-C-
PHASE DISTORTED WAVE IMAGE AT OUTPUT
2
120 CYCLES RIPPLE
TO Nos 1, 2 AND 3
1
INPUT FILTER COND. CHARGING CYCLES
1
2
3
RECT
3
PURE D.C.
-D-
ON ON INT. SW. 30
~CHECKING HUM RIPPLE VOLTAGE~

Fig. 63A—B—C—D

STOP GUESSING, Mister!

Use these 2 Ghirardi SERVICING BOOKS They'll tell you WHAT TO DO and HOW TO DO IT!

Alfred A. Ghirardi, world-known servicing authority, wrote these two great practical servicing books to give you EVERYTHING you need and want to know about radio service work as it is practiced today on factory test benches and by the most successful service shops.

●MODERN RADIO SERVICING—the 1300-page book—gives you a complete servicing "background." Everything about the latest servicing instruments, factory test and service methods and "tricks of the trade" is explained and made clear so you can learn "HOW."

●RADIO FIELD SERVICE DATA—the 436-page loose-leaf book of latest servicing reference data. It contains Case Histories for thousands of receivers, a complete tabulation of I-F Peaks, useful charts, tables, facts, all that indispensable mass of technical reference data that a serviceman needs constantly.

You NEED both of these books on your service bench right now. Send for them at once! Use the Easy-to-Order Coupon below.

MODERN RADIO SERVICING, $4.00
RADIO FIELD SERVICE DATA, $2.50

EVERY MINUTE YOU DON'T KNOW WHAT TO DO COSTS YOU HARD CASH!

"Modern Radio Servicing" *Tells you—*

HOW TO really understand and make best use of all varieties of servicing instruments—This 420-page section alone could well be considered a whole book on servicing instructions in itself. Complete with diagrams and construction data on all types of test equipment.

HOW TO apply the latest "factory" short-cuts in testing receivers in your own shop.

HOW TO repair every type of home or auto-radio receiver, old and new, with many new labor and time-saving methods.

HOW TO understand all the complexities and servicing of AVC and QAVC circuits.

HOW TO trouble-shoot and quickly get rid of all kinds of difficult troubles such as intermittent reception, hum, distortion, etc., etc.

HOW TO align and test receivers with Cathode-Ray Oscilloscopes.

HOW TO eliminate noise and all kinds of interference from all sets.

HOW TO service auto-radio, all-wave, high-fidelity, and other special receivers.

The "Field Data Book" *Enables you—*

TO cut down your servicing time by using the "Case Histories" of home and auto-radio sets it contains. This is the greatest collection of Case Histories in the world—over 1,500 of them in a special "quick-find" arrangement!—and more being added all the time in the Supplements.

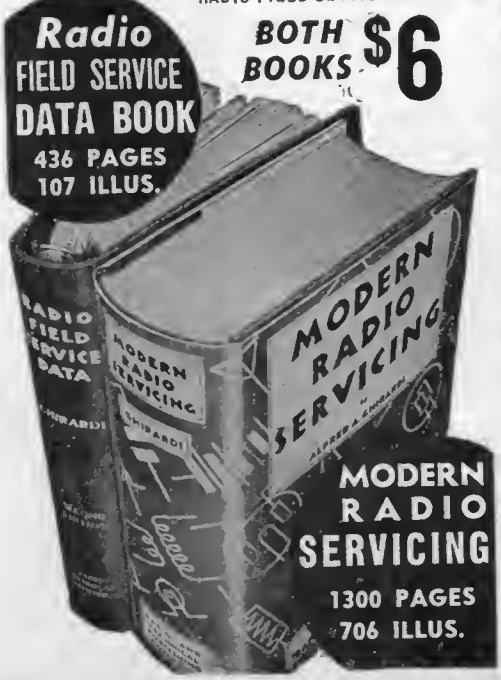
TO align superhets quickly—with the peak I-F Peak alignment data it provides for over 6,000 receivers.

TO save time in Auto-Radio servicing by utilizing the big collection of specialized auto-radio data, car ignition system data and electrical wiring diagrams, etc., which it gives for all American cars.

TO save work, worry and money by using the short-cuts you get in the big collection of 25 additional servicing data charts and tables you'll find in this handy time-saver!

HOW TO GET THESE 2 GREAT BOOKS

Fill out the Coupon below—or simply write your order on a piece of paper—and mail it right now before you turn this page! Books sent postpaid anywhere! You don't risk a single penny when you order these books—your money back if not thoroughly satisfied. Get your books this easy way!



RADIO & TECHNICAL PUBL. CO.
Dept. G-3, 45 Astor Place, New York

☐ Here is $6 for my copies of Ghirardi's MODERN RADIO SERVICING & RADIO FIELD SERVICE DATA (including Jan. & June '37 Supplements to Data Book), postpaid. (Foreign $6.50.)
☐ Please send me Free Circulars describing these books.

NAME .....
STREET .....
CITY ..... STATE .....

MONEY-BACK GUARANTEE!

Most progressive Service Men own, or use, a test oscillator as part of their regulator equipment. In order to obtain visual resonance curves of receivers, it is necessary to have both a test oscillator and some means of wobbling, or shifting the peak frequency above and below the resonance point. The device may consist of a vernier condenser rotated at high speed by a small motor; or it may be of the inductive type which is also motor-driven. A third type makes use of the vibrator principle. All three types are used in conjunction with a test oscillator and the Oscilloscope. A typical method of connecting the units to a receiver is shown. Using the same basic idea, it should be possible to wobble an audio-frequency oscillator to obtain visual audio response curves of each stage, or overall response of a complete amplifier. (At the present writing, we are informed that such an instrument is under development.)

DISTORTION ANALYSIS

The subject of audio distortion analysis is of great importance. The designers of modern home receivers, of the better type, make use of high-power, multi-tube audio amplifiers, which are more or less complex in structure. The average Service Man who is called upon to check audio distortion in any of these receivers, as a rule has no easy job on his hands. To begin with, the Service Man cannot be certain as to the origin of the distortion he is confronted with. With the Oscilloscope and a simple audio oscillator, it becomes a relatively simple matter to find the trouble, definitely and quickly.

We shall give one example of each of the three types of distortion which may be encountered in defective amplifiers.

Figure 63A is an example of *frequency distortion,* which shows that the amplifier does not amplify certain frequencies as well as it does others. For this type of test, it is necessary to use an audio oscillator with a continuously-variable frequency output. The oscillator output voltage, however, must not vary; as this would result in wavering of the wave-form traced on the Oscilloscope screen.

The second type of distortion, shown in Fig. 63B, is known as amplitude or *harmonic distortion.* In general, this is the type with which we have the most trouble. Amplitude distortion arises whenever a vacuum tube is operated beyond its linear characteristics; as, for instance, when overloaded. Harmonic frequencies appear in the output which were not present in the input. In addition to the tubes, a further possible cause of amplitude distortion may arise from impedance mismatching, or saturation of transformer cores and windings. A double check of this type of distortion is easily made with Oscilloscope and A. F. oscillator.

Phase distortion in audio amplifiers need not concern Service Men as a problem. A definition, however, might be of interest. When the phase relation existing *between* various frequencies, at the input, changes for any reason by the time the frequencies reach the output, a change in the original wave-form will result. The ordinary tone control, as an example, is a producer of phase distortion when it mutes the high notes. A test for phase distortion requires an A. F. oscillator which contains in its output harmonics sufficiently strong to appear in the waveform. See Fig. 63. This complex signal fed to the amplifier should be viewed on the Oscilloscope at both the input and the output. Any change in the wave-form will show that there is phase distortion in some degree. Both frequency and amplitude distortions must be at a minimum, or else they may be causing changes in wave-form at the same time.

Hum ripple may be studied and traced to its source by using the Oscilloscope as shown in Fig. 63D.

Checking selectivity, peak frequency and gain of I. F. transformers should be of interest to set builders. A setup for this purpose, which was used by the author, is shown in Fig. 63E.

Referring back to audio amplifier overload, a setup shown in Fig. 63F is used, and the following points must be observed: (1) both amplifiers in the Oscilloscope should be ON, or both should be OFF; (2) one amplifier alone should not be used; (3) no sweep voltage or synchronizing voltage is required for this test; (4) the gain of both amplifiers should be equal (if used), or else the diagonal line which appears on the screen will tilt.

the PERFECT Visual Alignment Combination

When you buy Supreme Visual Alignment equipment, you are assured of the very best design the fastest operation and the most accurate results—all at a price which gives you the greatest dollar value.

You get Supreme push-button tuning of all popular I.F. and R.F. alignment frequencies plus manual tuning on a giant dial with over 8 ft. of actual scale length and covering from 85 K.C. to 15 M.C. on fundamentals—above 60 M.C. on harmonics.

You get the one and only Supreme "Lock-center Synchronize" visual alignment circuit which prevents "floating" or "jiggling" images and does this automatically.

You get four types of output signals (1) Unmodulated R.F. so that you can externally audio modulate, (2) 400 cycle amplitude modulated R.F. for peak frequency adjustments, (3) variable band frequency modulated R.F. for creating on the scooe's screen a picture of the set's alignment and (4) a 400 cycle fixed audio note for testing P.A. and audio amplifiers.

MODEL 546 "SCOPE"

You get air tuned trimmers in the main tuning circuit. Special silver plated fixed capacitors and Isolantite based trimmers in the push button circuits.

You get the most complete yet lowest price 3" scope on the market with vertical and horizontal amplifiers, linear sweep circuit, "snap-lock" positive synchronization of all signals, all controls on front of panel.

You get direct access to scope deflecting plate circuits for DIRECT CURRENT measurements.

Finally, you get these instruments with a guarantee of perfection, backed by over a decade of successfully serving the radio industry.

Write us TODAY for your copy of our complete general catalog which illustrates and describes not only our visual alignment equipment but tube testers, analyzers, multi-meters and other fine test equipment. Remember, you can purchase any Supreme Instrument on the EASIEST Time Payment Plan in history. Just a few cents a day—little more than you pay for your "smokes"—will bring you the finest testing equipment. Don't delay—write today!

MODEL 582 PUSH BUTTON SIGNAL GENERATOR

SUPREME INSTRUMENTS CORP.

GREENWOOD, MISSISSIPPI, U. S. A.

EXPORT DEPT., ASSOCIATED EXPORTERS CO., 145 W. 45th STREET, NEW YORK CITY, CABLE ADDRESS: LOPREH, NEW YORK

In conclusion, the author suggests that the Service Men who have built the Oscilloscope keep a record of the connections, and a tracing of unusual images, in a note-book set aside for that purpose, so that in time, they will have at their disposal an operating manual of great utility.

◆ ◆ ◆

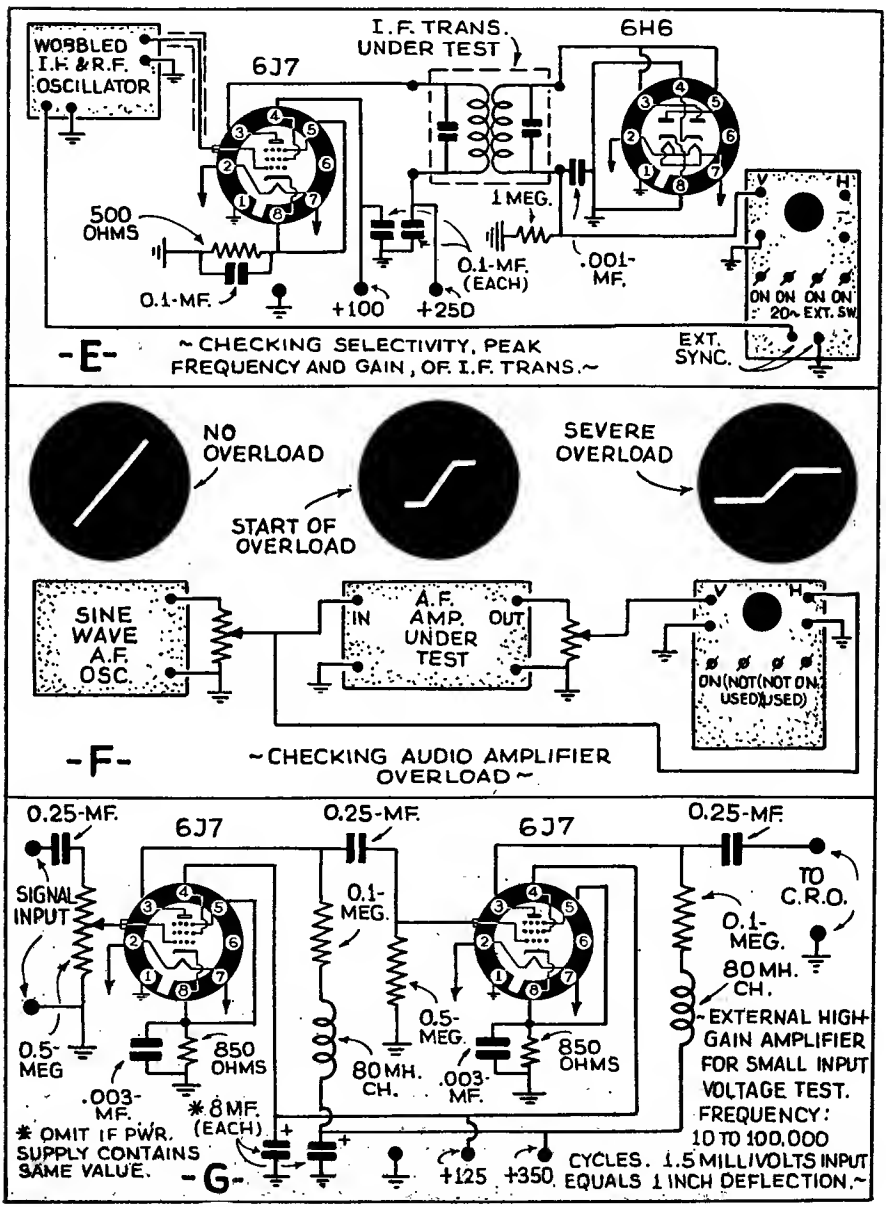


Fig. 63 E—F—G

C-B Only C-B Graphoscopes Offer These ADVANCEMENTS!

QUALITY STANDARD OF THE RADIO INDUSTRY

SUPERIOR performance characteristics and dependability are coupled with astonishing ruggedness and compactness in the C-B 126 Graphoscope, measuring only 9¼" x 9" x 13", and weighing only 21 lbs.

Reflecting the completeness of improvement throughout is the demountable tube shade, for improved visibility of trace at reduced voltage, and correspondingly reduced risk of costly tube replacement.

Height of 9¼"—uniform for C-B instruments—contributes to orderly, impressive customer-arresting display of complete C-B apparatus assemblies, whether in factory-made racks or custom-built installations.

ANTI-CAPACITY DEMODULATOR

Avoids error produced by self-contained demodulators in misalignment and distortion of signal image through high capacity effect of test leads at radio and intermediate frequencies. The roving tube correctly brings the demodulator into the receiver circuit, instead of extending the circuit to the demodulator, and so avoids upset of receiver constants. Applicable to any oscilloscope without change.

Delivers Only Wanted Signal

Alone among combination instruments, C-B ten-tube Model 127 delivers only the wanted signal, free from confusing, time-wasting harmonics. Key instrument of eye-arresting and customer-convincing visual examination, it is the cornerstone to better service at better rates of pay. Provides full visual coverage of receiver stages, from antenna to speaker. No demodulator needed. Clough-Brengle Co., 2839 W. 19th St., Chicago.

C-B Laboratory Graphoscope No. 126 $64.50

With Uni-Signal Freq. Mod., No. 127 $93.50

CHAPTER 7

Solving Unusual Problems With The Oscillograph

Automatic Frequency Control, better known as AFC, is becoming increasingly popular in modern receivers, especially those receivers using some form of Automatic tuning. Most of these receivers use a specialized form of I. F. transformer which is designated as the Discriminator transformer. When the trimmers are properly adjusted, the output curve of this transformer resembles an S, and is symmetrical on both sides of resonance. Fig. 45 shows the difference in the appearance of the curves for the regular I. F. transformer and the Discriminator type.

The method of connecting the Oscillograph to the AFC output terminals depends on the particular variation of the circuit being used. One must also remember that it is essential to use a frequency-modulated signal generator, in order to produce a band of frequencies at least 20 kc. wide.

Tracing hum pickup in receivers and amplifiers is an extremely important operation, in which the Osciliograph and a sine-wave audio oscillator are of great help. The usual method is to impress a sine voltage of 6000 cycles from the A. F. oscillator to the amplifier input.

With the Oscillograph sweep adjusted to exactly 60 cycles, 100 complete cycles of the A. F. oscillator, which will look somewhat like the teeth of a comb, will appear on the screen. If these cycles are all exactly in line and form a straight edge at top and bottom, it denotes a complete lack of hum or harmonics. On the other hand, if there is an undulating movement of the rectangular pattern, it proves a modulating voltage is present in the output. This undulation may be caused by hum voltage, harmonics, motor-boating or regeneration. Fig. 42 gives the appearance of the pure sine-wave output and the hum-modulated wave.

To localize the point at which hum is introduced into the circuit, the Oscillograph is connected from input to output, progressively. That is, from 1st A. F. grid to ground; then from 1st A. F. plate to ground; and so on until the offending stage is found.

In all the more expensive high-fidelity receivers, capable of reproducing frequencies as high as 15,000 cycles, will be found a filter circuit which is adjustable to trap the 10-kc. beat produced between channels.

The correct adjustment of such a trap circuit is critical, and can best be accomplished through the use of an audio oscillator and an Oscillograph. An idea of the sharp cut-off characteristics of such a filter can be gained from Fig. 43, which shows the appearance of the pattern when the trap circuit is properly adjusted. The audio oscillator is adjusted to 10,000 cycles and its output is fed into the demodulator output. No R. F. signal should be allowed to enter the demodulator input during the test.

The Oscillograph is connected across the speaker voice coil, or across the primary winding of the output transformer. With the Oscillograph sweep set at 100 cycles or so, a rectangular pattern is obtained. The amplitude, or height, of the pattern on the screen depends on the strength of the 10,000-cycle wave, produced by the audio oscillator and reproduced by the audio system of the receiver. The correct adjustment then consists of reducing this amplitude to zero, corresponding to a straight line on the screen. Shifting the audio oscillator to 9,000 cycles and 11,000 cycles, alternately, should produce a wave amplitude as large as the original 10,000 cycle wave, with a sharp decline to zero when the audio oscillator passes through the 10 kc. setting.

The method used to determine the lowest and highest frequency limits of audio amplifiers requires, as before, an audio oscillator and the Oscillograph. In addition, a transparent screen, marked with vertical and horizontal lines, should be affixed over the Cathode-Ray tube screen. The import-

JACKSON

The New Model 601

"VISULINE LAB"

A COMPLETE CATHODE RAY Alignment Laboratory in standard relay rack style. The Model 601 rack contains two separate instruments perfectly matched, for use in all receiver alignment problems.

The OSCILLOGRAPH is the standard 3" size with built-in sweep, dual amplifiers etc. The OSCILLATOR is the now famous JACKSON Model 420 UNIVERSAL type. THE FINEST EQUIPMENT AVAILABLE, REGARDLESS OF PRICE.

Write for free catalog "L"

THE JACKSON ELECTRICAL INSTRUMENT CO. • Dayton, Ohio

ant thing to remember in this type of test is that the value of input voltage (from the oscillator to the amplifier) must be exactly the same for each frequency setting.

Instead of using the speaker and output transformer, a resistor of the proper wattage, and of the correct resistance to match the load conditions of the particular output tubes, must be used. The vertical deflector of the Oscillograph is connected across this load resistor for the measurement test.

Assuming that 1 volt input will be used throughout the test, it will be first necessary to measure the oscillator output, and to adjust its output control to 1 volt, by measuring the height of the pattern on the screen of the Oscillograph. (The height should be exactly one-half inch.) The vertical amplifier in the Oscillograph must be turned to maximum and left in this position during the test.

The oscillator output is then applied to the grid of the first tube in the amplifier. We will assume further that the oscillator will be adjusted to produce frequencies in the following order: 40 cycles, 100 cycles, 200 cycles, 400 cycles, 1000 cycles, 3000 cycles, 7000 cycles, 10,000 cycles and 15,000 cycles.

The output control on the oscillator will have to be readjusted each time the frequency setting is changed, so that a 1 volt input will be applied to the first A. F. grid in each case.

The output of the amplifier is measured off in inches, on the transparent screen, for each frequency setting. A curve may be drawn from the values obtained, and thus provide a graphic representation of the gain at the limits, and throughout, the range, of the amplifier.

The same general method applies when it is required to determine the low-and high-frequency limits of wave filters. The determination of the low-and high-frequency attenuation of wave filters requires that the input signal be gradually reduced in amplitude by the filter; so that the pattern diminishes on the screen, at the frequency which the filter is designed to attenuate.

◆ ◆ ◆

J. E. SMITH, President
National Radio Institute
Established 1914

The man who has directed the home study training of more men for the Radio Industry than any other man in America

I WILL TRAIN YOU TO START A SPARE TIME OR FULL TIME RADIO SERVICE BUSINESS WITHOUT CAPITAL

Do you want to make more money? The world-wide use of Radio has made many opportunities for you to have a spare time or full time Radio service business of your own. Three out of every four homes in the United States have Radio sets which regularly require repairs, servicing, new tubes, etc. Many sets are old and will soon be replaced by new models. I will train you at home in your spare time to sell, install, service, all types of Radio sets—to start your own Radio business and build it up on money you make in your spare time while learning. Mail coupon for my 64-page book. It's Free—it shows what I have done for others.

Here's Proof

Earned $50 First Month in Spare Time

"I knew nothing about Radio. After four lessons I began servicing Radios, earning $50 the first month. Last winter I made as high as $100 a month in spare time."—G. F. WALTON, 808 West Olney Road, Norfolk, Va.

Own Business Pays $300 a Month

"I now have my own Radio business which shows three hundred dollars a month profit — thanks again to National Radio." FRANK T. REESE, 39 N. Felton St., Philadelphia, Penna.

Many Make $5, $10, $15 a Week Extra In Spare Time While Learning

Practically every neighborhood needs a good spare time serviceman. The day you enroll I start sending you Extra Money Job Sheets. They show you how to do Radio repair jobs that you can cash in on quickly. Throughout your training I send plans and ideas that have made good spare time money for hundreds of fellows. I send special equipment which gives you practical experience—shows you how to conduct experiments and build circuits which illustrate important Radio principles.

There's A Real Future in Radio for Well Trained Men

Radio already gives good jobs to more than 300,000 people. And in 1936, Radio enjoyed one of its most prosperous years. More than $500,000,000 worth of sets, tubes and parts were sold—an increase of more than 60% over 1935. Over a million Auto Radios were sold, a big increase over 1935. 24,000,000 homes now have one or more Radio sets, and more than 4,000,000 autos are Radio equipped. Every year millions of these sets go out of date and are replaced with newer models. More millions need servicing, new tubes, repairs, etc. A few hundred $30, $50, $75 a week jobs have grown to thousands in 20 years. And Radio is still a new industry—growing fast!

Get Ready Now for Your Own Radio Business and for Jobs Like These

Broadcasting stations employ engineers, operators, station managers and pay up to $5,000 a year. Spare time Radio set servicing pays as much as $200 to $500 a year—full time servicing jobs pay as much as $30, $50, $75 a week. Many Radio Experts own their own full or part time Radio businesses. Radio manufacturers and jobbers employ testers, inspectors, foremen, engineers, servicemen, paying up to $6,000 a year. Radio operators on ships get good pay and see the world. Automobile, police, aviation, commercial Radio, and loud speaker systems offer good opportunities now and for the future. Television promises many good jobs soon. Men I trained have good jobs in these branches of Radio.

Find Out What Radio Offers You Get My 64 Page Book Free Now

Act Today. Mail the coupon now for my Free Lesson and my book, "Rich Rewards in Radio." Both are free to anyone over 16 years old. My book describes Radio's spare time and full time opportunities and those coming in Television; tells about my Training in Radio and Television; shows you actual letters from men I have trained, telling what they are doing and earning, tells about my Money-Back Agreement. Find out what Radio offers YOU! MAIL THE COUPON in an envelope, or paste it on a penny post card—NOW!

GET FREE LESSON on Radio Servicing Tips

Here's proof that N. R. I. Training is practical, money-making information, that it is easy to understand—that it is just what you need to master Radio. The sample lesson text, "Radio Receiver Troubles—Their Cause and Remedy," covers a long list of Radio receiver troubles in A. C., D. C., battery, universal, auto, T.R.F., superheterodyne, all-wave and other types of sets. Get this lesson Free. Mail Coupon.

J. E. SMITH, President, Dept. 7JA1,
National Radio Institute, Washington, D. C.

GOOD FOR BOTH 64 PAGE BOOK SAMPLE LESSON FREE

J. E. SMITH, President, National Radio Institute
Dept. 7JA1, Washington, D. C.

Dear Mr. Smith: Without obligation, send me the Sample Lesson and your book about spare time and full time Radio opportunities, and how I can train at home in spare time. (Please write plainly.)

Name..... Age.....

Address .....

City..... State.....14X1

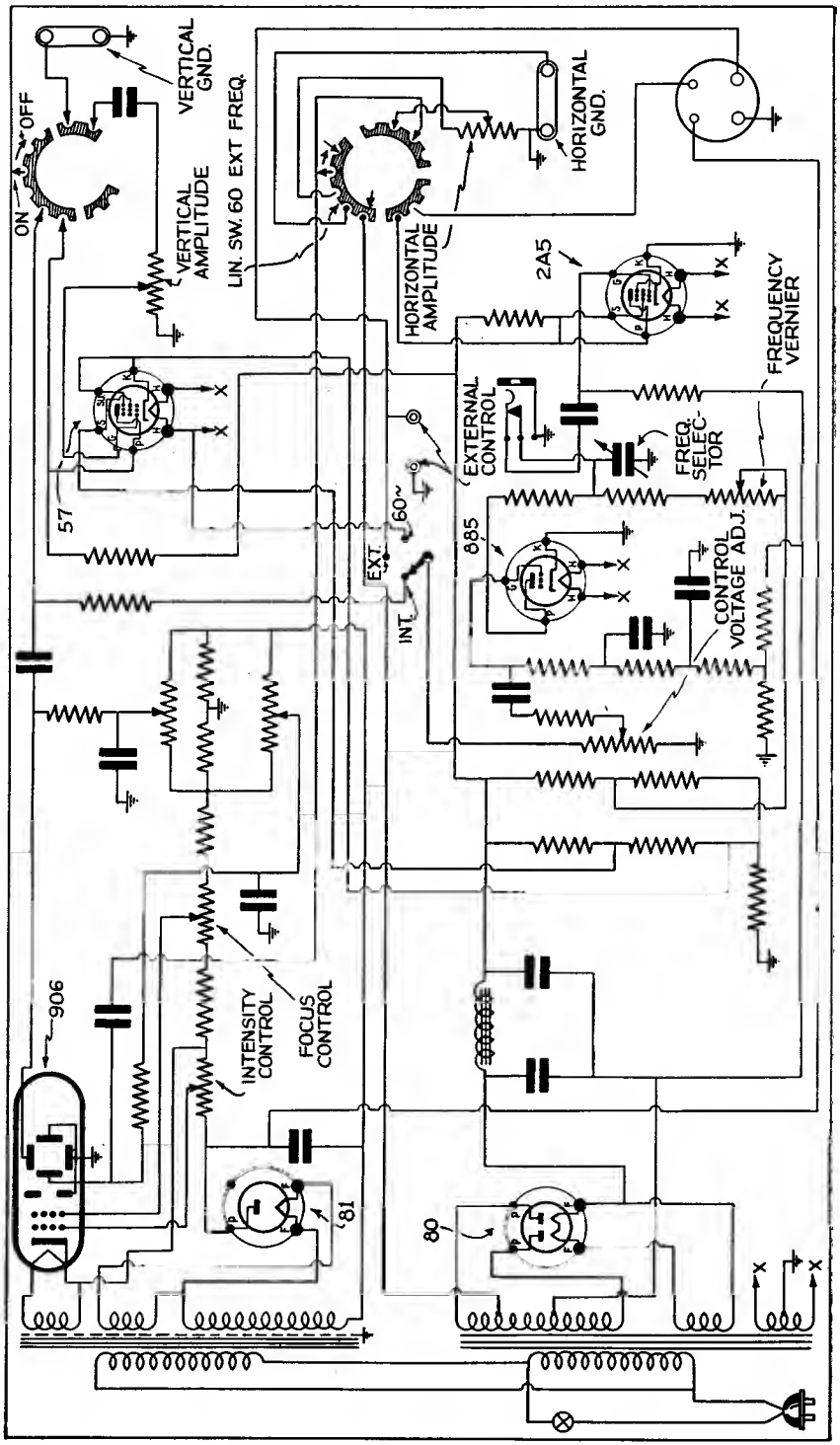


Fig. 65. Clough-Brengle Model CRA

COMPLETE COVERAGE

HICKOK

Presents

The Only Complete

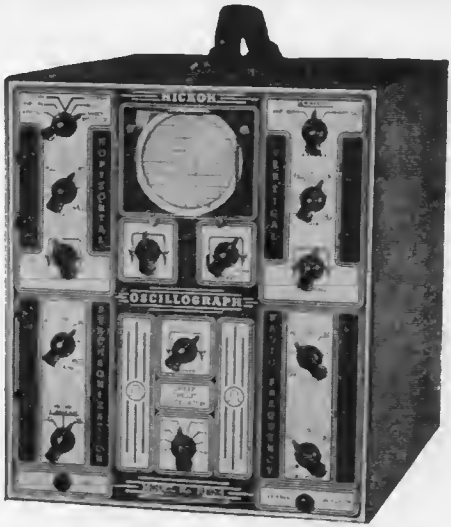
OSCILLOGRAPH

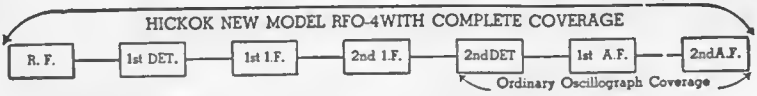
Model R F O-4

WITH SELF-CONTAINED

DEMODULATOR

and Frequency Modulator





OUTSTANDING FEATURES OF THIS REMARKABLE INSTRUMENT:

- NEW SELF-CONTAINED DEMODULATOR makes it possible to use this oscillograph in R.F., I.F. and A.F. stages. Also permits single or consecutive stage by stage trouble shooting from the antenna post to speaker.
- SELF-CONTAINED DUAL SWEEP ELECTRONIC FREQUENCY MODULATOR simplifies connections, makes possible selectivity measurements and permits visual alignment at 665 KC or any harmonic thereof to 5 megacycles without the use of an external oscillator and at any frequency with an external oscillator.
- Return trace eliminator simplifies alignment of A.F. and R.F. circuits.
- Dual sweep permits development of any type single or double response curve.

And Many Other Valuable Features. Send for Complete Catalog of This and other Hickok Radio Testing Instruments

THE HICKOK ELECTRICAL INSTRUMENT CO.

10429 Dupont Ave. . . . . Cleveland, Ohio

FREE

48-PAGE

ILLUSTRATED

BOOK

Describing the Use of

CATHODE RAY TUBES IN TELEVISION

You men who are interested in getting into Television are cordially invited to send for your Free copy of this fascinating Book. It shows you the new advanced methods of Cathode Ray Tube use in Television. Written in a simple, easy to understand way, by nationally known electronic and television engineers. 48 pages of interesting, valuable data not found in any other book . . new developments . . . new illustrations . . . new diagrams . . . new theories. Nothing like it anywhere. It's FREE!

AMERICAN TELEVISION INSTITUTE
433 E. ERIE ST. DEPT. G58, CHICAGO, ILL.

Gentlemen: Please send me, postpaid, a copy of your FREE 48-page book on Cathode Ray Tubes in Television. No obligation. Also details on how I can get in on the ground floor of Television.

Name ..... Age .....

Address .....

City ..... State .....

Send Coupon

No Obligation

Which of These
FAMOUS VOLUMES ON RADIO SERVICING
Do You Need to Complete Your Files?

There's perhaps one or more of these great service manuals which you might need to complete your set. Collectively they represent the largest collection of service data ever compiled. Evidence of their importance to Radio men is shown by the fact that over 80,000 OFFICIAL RADIO SERVICE MANUALS have been sold during the past few years.

1936 OFFICIAL RADIO SERVICE MANUAL
1,200 Pages — Over 2,500 Illustrations — 9x12 Inches — Looseleaf Binder, Hard Covers
LIST PRICE $7.00

OFFICIAL RADIO SERVICE HANDIBOOK
Over 1,000 Pages — Over 1,000 Illustrations — 6x9 Inches — Hard Cover
LIST PRICE $4.00

1935 OFFICIAL RADIO SERVICE MANUAL
Over 1,000 Pages — Over 3,000 Illustrations — 9x12 Inches — Flexible, Looseleaf, Leatherette Cover
LIST PRICE $7.00

1934 OFFICIAL RADIO SERVICE MANUAL
Over 400 Pages — Over 2,000 Illustrations — 9x12 Inches — Flexible, Looseleaf, Leatherette Cover
LIST PRICE $3.50

1933 OFFICIAL RADIO SERVICE MANUAL
Over 700 Pages — Over 2,000 Illustrations — 9x12 Inches — Flexible, Looseleaf, Leatherette Cover
LIST PRICE $5.00

1932 OFFICIAL RADIO SERVICE MANUAL
Over 1,000 Pages — Over 2,000 Illustrations — 9x12 Inches — Flexible, Looseleaf, Leatherette Cover
LIST PRICE $5.00

1931 OFFICIAL RADIO SERVICE MANUAL
650 Pages (Including Supplements) — Over 1,500 Illustrations — 9x12 Inches
Flexible, Looseleaf, Leatherette Cover
LIST PRICE $4.50
(Including Supplements)

For Car-Radio Servicing —Get These
OFFICIAL AUTO-RADIO SERVICE MANUALS

1935 MANUAL
Over 240 Pages — 9 x 12 Inches
Over 500 Illustrations
Flexible, Looseleaf, Leatherette Cover
LIST PRICE $2.50

1933 MANUAL
Over 240 Pages — 9 x 12 Inches
Over 500 Illustrations
Flexible, Looseleaf, Leatherette Cover
LIST PRICE $2.50

Send remittance for any OFFICIAL RADIO SERVICE MANUAL in form of check or money order. Register letter if it contains cash or currency. ALL MANUALS ARE SENT POSTAGE PREPAID.

RADCRAFT PUBLICATIONS, Inc.
99-CR HUDSON STREET . NEW YORK, N. Y.

Let these eminent Radio Authors guide you through your radio service work!

The importance of Radio Service Men can be appreciated when it is realized that of the 16,000,000 radio sets in the world, over one-half of that number are in use in this country. Approximately 15,000,000 must be serviced, and the Radio Service Men are the only ones that can do the job.

RADIO-CRAFT is published exclusively for Service men. It is edited with the view to give the Service Man the latest and most valuable service information obtainable. It is the magazine you need if you want to be successful in radio service work.

The list of contributors shown at the right represents the finest corps of independent radio writers in the field of any publication. These writers are continually working for your benefit.

Get a copy of the current issue of RADIO-CRAFT from your newsdealer today—read it from cover to cover. Then judge for yourself if it is not the finest service magazine published today. Once you have read your first issue, you'll never let a month pass without getting the next one.

We will send you RADIO-CRAFT for One Year at the Special Rate of $1.00 (Foreign $2.00). This is a saving of 1/2 over the regular subscription rate. Send remittance in form of check, stamps or money order to

Editors of
RADIO-CRAFT

HUGO GERNSBACK
Editor-in-Chief

R. D. WASHBURNE
Managing Editor

N. H. LEIDEN
Associate Editor

C. P. MASON
Associate Editor

•

Contributors to
RADIO CRAFT

M. M. Fridge
Kendall Clough
A. A. Ghirardi
Glenn H. Browning
Charles Sequeira
Samuel C. Hillmusa
F. L. Dungybelly
Allen H. Lynch
A. C. Bailey
Benham M. Freed
J. B. Carter
Clifford E. Denton
Milton Reiss
Frank J. Lester
J. T. Bentley

RADIO-CRAFT MAGAZINE
96 CR HUDSON STREET NEW YORK, N. Y.